POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

Contents

WE DO OUR PART

A Case of Open Defiance of the NRA 164

With the Editors 165

Hidden Opportunities for Saving. U. S. S. R. Favors American Engineers and Equipment.

Modernization of Newton Pumping Station Increases Capacity and Efficiency 166

State Surface of Steam Visualized. By R. L. Scorah 172

Tubes May Solve Your Problems. By Hendley N. Blackmon 174

Maintenance and Repair Schedules 178

Waterwheel Efficiency of Hydroelectric Units. By J. F. Richmond 179

Fitting the Turbine to the Plant. By H. S. Hemenway 180

The Boiler Heat Balance and Its Calculation. Part II. By Albert E. Canfield 182

Short Cut High Temperature Tests 185

Fundamentals of Power Plant Piping Design. By Henry C. Moffett 186

Largest Single Phase Waterwheel Generator 188

Vapor Refrigeration System Characteristics. By Paul Bancel 189

Automatic Reclosing of Oil Circuit Breakers. By A. E. Anderson 192

Diesel Diagnosis with Indicator and Pyrometer. By William Sheffer 194

Readers Conference 196

Pulsations in Gravity Bucket Conveyor Chains. Welded Boilers. Pointers on Belt Selection. Water Hammer in Steam Pipes. Doubling in Brass. Variable Pressure Boiler Operation. Air for Air Chamber. Carelessness Causes Oil Fire Explosion. Quick Improvised Expansion Foundation Bolt. Excess Slip in Induction Motors. Concrete for Small Jobs.

Foxboro Controllers. Westinghouse Right Light Meter. Monobelt, A New Type of Leather Belt. The G. E. Impulse Breaker 200

Oil Heater. V-Eight Diesel. Temperature Control. New Thyrite Station-Type Lightning Arresters 201

Morse-Kelpo One-Way Clutch. Brush Seater. New Across-the-Line Starter. Pipe Coupling. Ball Bearing Liquid Level Control 202

Single Reduction Gear Motors. Air Compressor. New Condit Motor Operator. Appalachian Electric Power Co. Denied Appeal. Willard Elected U. of I. President. Robins Acquires Mead-Morrison Co. Lamme Medal Awarded to Lewis B. Stillwell 203

Frank R. Wheeler 204

News From the Field 204

For the Engineer's Library 204

Power Plant Construction News 206

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

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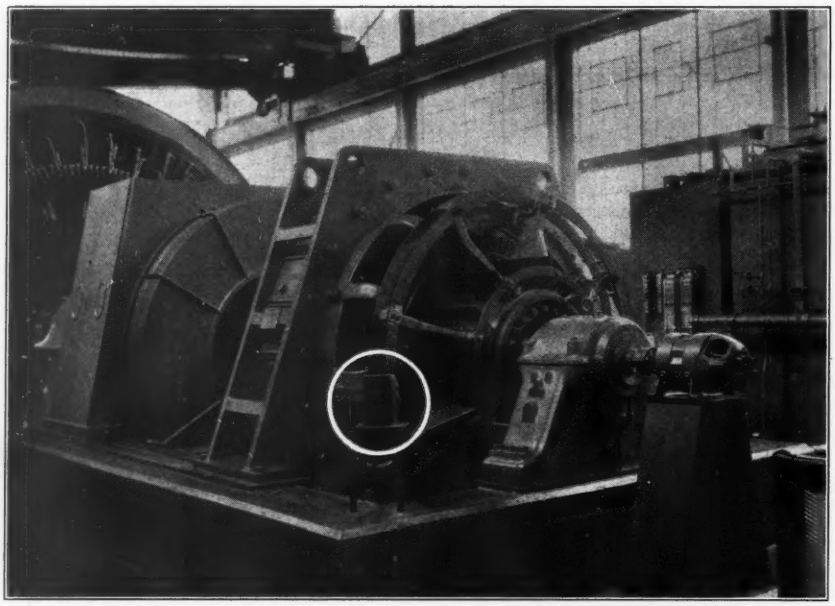
A Case *of* Open Defiance *of the* NRA



YOU HAVE ALL heard of certain avaricious individuals who under various pretexts and subterfuges manage to avoid the rules of the NRA with respect to working hours. Well, here is a most brazen example of this sort of thing and we hope General Johnson sees this picture so he can do something about it. True, we haven't heard of a "Watchman's" code yet, but that doesn't mean anything—there are lots of things we haven't heard about though we don't always admit it. However, code or no code, here we have a picture of a watchman in action, one who insists upon working not only 8 or 10 hr. a day but 24! Just think of it, 24 hr. a day, seven days a week! Can you imagine anything like that, patriotic reader? No? Well, neither could we until we saw this picture, but here is the incontrovertible evidence.

For your benefit, we have put a circle around the watchman. There he sits, firmly rooted to his job by a number of steel bolts, watching the commutator of the converter for flashovers. When a flashover starts to occur, it is his duty to cut the power off and shut the machine down. Rather monotonous, don't you think, but not for a photoelectric tube with only a vacuum in its head.

All joking aside, this is a remarkable example of what a vacuum tube can accomplish. This cell, enclosed in a steel protective housing, is so arranged that light from a flashover on the commutator enters the photocell and causes it to actuate relays which in turn open the main power circuit to the machine. Thus the instant a flashover occurs the machine is shut down preventing serious damage.

In itself this application is quite simple but the truly remarkable thing about it is the speed at which the action takes place. So rapid and so sensitive is this arrangement that it acts to suppress the flashover before the eye can discern any evidence of flashover. The cell sees the flashover in its most incipient stages.

This is only one of many possible applications of the vacuum tube in the power industry, in fact the possibilities are almost unlimited. Every day new uses for this marvelous device are being found and scarcely a week goes by without the development of a new type of tube.

It is natural that to many engineers, this new device should possess an element of mystery and that they hesitate to attempt its application in their own plants. It is something with which they never have had experience, as a consequence, they tend to avoid it.

It is unfortunate that this is so for in reality the vacuum tube, though complex from a theoretical standpoint, is quite easy to understand, practically. To prove this assertion, we are presenting in this issue the first of two articles on vacuum tubes written entirely from the standpoint of the practical man and devoid of all complexity. Read them. You will find them most interesting and we feel certain that they will dispel some of the mystery which surrounds this newest tool of the electrical engineer.

There is another article in this issue which deals with a subject that to many perhaps is even more mysterious than the subject of electron tubes. We refer to the article on page — discussing the "state surface of steam." What on earth is meant by the "state surface of steam"? As a matter of fact we didn't know that steam had any surface. All the specimens that we have examined have been so characterized by volume that we never stopped to look at its surface. But as we said before, the mere fact that we had not heard about it doesn't mean anything and so we can inform you now with very perfect assurance that we know what we are talking about, that steam has a surface—a state surface to be correct. There was not room on this page to show you a picture of it but if you will turn to page 172 you will actually find a picture of the state surface.

WITH THE EDITORS

Hidden Opportunities for Savings

WE ONCE HEARD of a manufacturer worth several millions of dollars by virtue of an inheritance, who, when he noticed that the whistle at one of his factories blew rather a long time at noon, calculated (with assistance, no doubt) the cost of the steam involved and deducted this from the engineer's salary. Whereupon he boasted of his ability as an executive.

This incident which we have good reason to believe actually occurred, unfortunately is typical of many people's attitude in regard to saving money. It is quite likely that in this same manufacturer's plant there were dozens of places where there were losses equal to many times those incurred by the whistle but since they were less obvious to his simple mind were permitted to continue unrestricted. Furthermore, it is also likely that if some of these less obvious losses had been directed to his attention by his engineer he still would have ignored them because of his inability to understand the engineering principles involved and his inherent distrust of technical matters.

This perhaps is an extreme case and it is reasonable to suppose that no amount of logical argument could influence the eccentric mental processes of that type of mind, but there are no doubt many instances where executive opposition can be overcome to a certain extent by the presentation of facts in suitable form. This has always been, and probably always will be, the major problem confronting the power plant engineer—that of explaining to executives in non-technical terms opportunities for saving money based on engineering study.

Today in the power plants throughout the nation there are enormous opportunities for reducing the cost of power. There are thousands of plants of small and moderate capacity using equipment which though perhaps in good operating condition and apparently producing revenue, is nevertheless a financial burden because of obsolescence. Just because a machine, or a plant, continues to operate with little or no trouble is no indication that it is economical. In one instance which we described in these pages recently there had not been a single power or mechanical interruption due to failure of equipment in the power plant for a period of over 13 yr. Yet when this plant was rebuilt, substituting modern equipment for the old, the operating cost for a period of 5½ months decreased from $80,906 to $45,671, a gross saving of $35,235.

What was possible at this plant is possible to greater or less degree in thousands of other plants. Power, it must be remembered, is a commodity that is produced continually, usually without interruption, 24 hr. a day, six or seven days a week and even apparently minute reductions in unit costs over a long period of time pile up astonishing savings.

Such opportunities for effecting savings are not obvious. An executive cannot find them by listening to the whistle or looking at the stack. It is only when the engineer directs his attention to them, in terms that he can understand, that he becomes sufficiently interested to issue the necessary executive authority to have them put in effect. This involves more than mere technical knowledge on the part of the engineer, it involves salesmanship, and diplomacy as well, but unless the engineer possesses the necessary technical knowledge, the other two attributes don't count for much. His first job is to find these hidden opportunities for saving.

U. S. S. R. Favors American Engineers and Equipment

THE ESTABLISHMENT of normal relations between the Soviet Union and America opens up broad commercial possibilities for American manufacturers of machinery and equipment. Such opportunities, it is true, have existed for the past ten years or more and a number of American firms taking advantage of these opportunities have profited handsomely despite the absence of normal political and economic relations, but now that normal relations have been resumed, the opportunities for close commercial relations are greater than ever before.

Soviet engineers favor American methods and equipment. In a recent article in the Russian newspaper "Technique" Engineer A. Zaviniagin, who is at present superintendent of the Magnitogorsk Combine, gives high praise to American methods and his dealings with American engineers. Referring specifically to the well known group of American engineers of the Freyn Engineering Co., who supervised the erection of nearly all of Russia's new giant steel plants, Zaviniagin says, "To work with Americans is a real pleasure. Broad engineering experience, an understanding of the high scale of reconstruction of Soviet ferrous metallurgy, a splendid knowledge of all the details of metallurgical operation, an excellent orientation to our conditions, and an attitude of full mental understanding between ourselves and the American specialists—this is the style of the American engineers. Not accidentally have American engineers become in a short time real friends of our workers."

In view of the fact that the development of industrial Russia has scarcely begun, this expression of opinion by this Soviet official is of considerable significance. What is true of the steel industry regarding magnitude and efficiency of American technique is equally true of other industries, including the power industry. In future years there will be an increasing demand for power in Russia and to those American manufacturers who have the foresight to establish effective coöperation with the Soviet engineers will go the opportunity of building plants and selling equipment. The fact that the Soviet engineers are pleased with American methods and design places our industries at a distinct advantage with respect to European manufacturers. The success of the Freyn Engineering Co. in the development of the Russian steel industry can be duplicated in other industries by those who have the necessary foresight and initiative.

The Newton Pumping Station as it appears today.

MODERNIZATION of a power plant often involves engineering problems which are more difficult of solution than those connected with the design of new plants. There are several reasons for this; in the first place, in rehabilitating an old plant it is usually necessary to maintain at least partial service while the work of modernizing is in progress. This always brings up problems which demand skill and resourcefulness in their solution and which often call for unusual measures. Secondly, the rehabilitation of an old plant invites a most interesting comparison between existing old equipment and the new. It provides a very definite measure of progress in engineering and equipment design.

For these reasons the recent rehabilitation of the city pumping station in the City of Newton, Massachusetts, just outside of Boston, is of considerable interest. It is one of the most interesting instances of modernization we have seen and one which from the standpoint of improved efficiency fully justified the expense involved.

Newton is an important suburb of Boston. It is almost entirely residential and has a population of about 70,000. Since the homes are those of the well-to-do class, the demands for water are considerable and a high quality of service must be maintained.

Until about a year ago these water requirements were met by the old Needham Street Pumping Station. This station consisted of two pumping engines, one a vertical Barr unit of 5,000,000 gal. capacity, about 28 yr. old, and the other a Worthington, horizontal direct acting pump over 50 yr. old. These machines were supplied with steam by two 300 hp. firebox type boilers, hand fired and about 42 yr. old. With these boilers and engines, at no time did the total capacity of the station exceed 5,000,000 gal. per day. A view of the old pump room with the Barr engine in the foreground and the Worthington unit at the right is shown in Fig. 1. Contrast this picture with the one of the new pump room shown in the illustration at the head of this article and you will see what rehabilitation really means.

For these two views are of the same room, before and after. The building itself was practically unchanged. The same walls and roof lowered 10 ft. from original position serve the new station as they did the old. The old pump room floor was removed, however, and the present floor of the pump room is in reality the basement floor of the old plant. This accounts for the difference in level of the windows evident in the two photographs. In the boiler room, the floor was lowered about a foot. The roof of the boiler room is supported on two timber trusses dividing the width of the building into three equal bays. The headroom under these trusses of 18½ ft. was not sufficient to accommodate the new boilers so the arrangement adopted was to locate one boiler in each outside bay and to locate the auxiliary equipment in the central bay. This arrangement will be described in more detail later.

MODERNIZATION OF NEWTON PUMPING STATION INCREASES CAPACITY AND EFFICIENCY

The old pumping units have been replaced by three turbine-driven centrifugal units, each of different capacity but of identical design. The pumping ratings of these units are as follows:

Unit No. 1.....4,250,000 gal. per day
Unit No. 2.....6,000,000 gal. per day
Unit No. 3.....8,000,000 gal. per day

These machines are of rather unusual design. Each unit consists of a condensing, extraction type turbine, a reducing gear, an alternating current generator, a direct current exciter and two centrifugal pumps connected in series, all on one shaft. They are of De Laval manufacture, and assembly though the electric generators and exciters were supplied by the Electric Mach. Mfg. Co. The size of the pump units vary, but generators on the three units are all alike. They are 250 kv-a. generators, wound for 4000 v. 60 cycle 3 phase.

The reason for this arrangement lies in the fact that this pumping station is not located directly at the source of supply. The water is obtained mostly from two large dug wells at the water works reservation about two miles from the pumping plant. It is to operate the motors driving these well pumps and also two flooding pumps that the generators are provided. Current generated at 4000 v. is transmitted directly at this voltage to the reservation where it is delivered to the pumps. For station use the voltage is reduced to 110 and 220 for lighting and for motor driven auxiliary service.

The three pumping units are all geared down to a speed of 1200 r.p.m. The turbine speed of one of the machines is different from the other two, however. This is the smallest unit (No. 1) which has a speed of 5980 r.p.m. whereas the two larger machines run at 6060 r.p.m. The turbines are 9 stage, De Laval, extraction units, taking steam at 230 lb. gage and with 125 deg. of superheat and exhausting into surface condensers operating at a 29 in. vacuum. Unit No. 1 is rated at 600 brake horsepower, No. 2 at 775 b.hp. and No. 3 at 1000 b.hp.

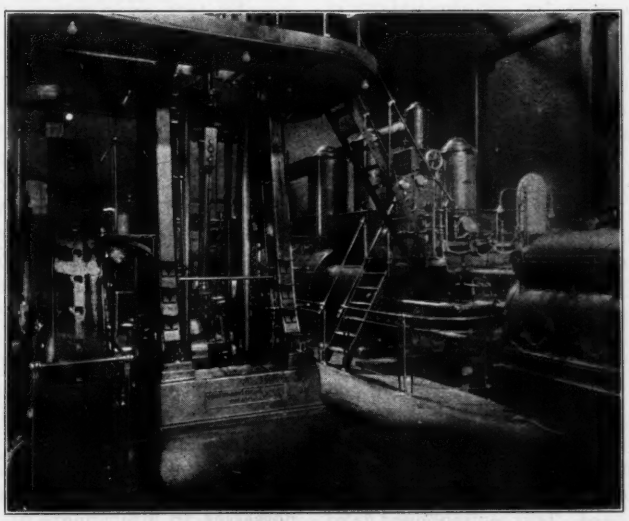


FIG. 1. THE OLD STATION BEFORE REHABILITATION
This is the same room shown in the view on the opposite page. In the foreground is shown the vertical Barr Pumping Engine, at the right the Worthington horizontal.

The turbines exhaust into Foster-Wheeler waterworks type surface condensers, located in the suction piping, and equipped with steam ejector type air pumps which are fitted with inter and after surface condensers. All the water handled by the pumps passes through

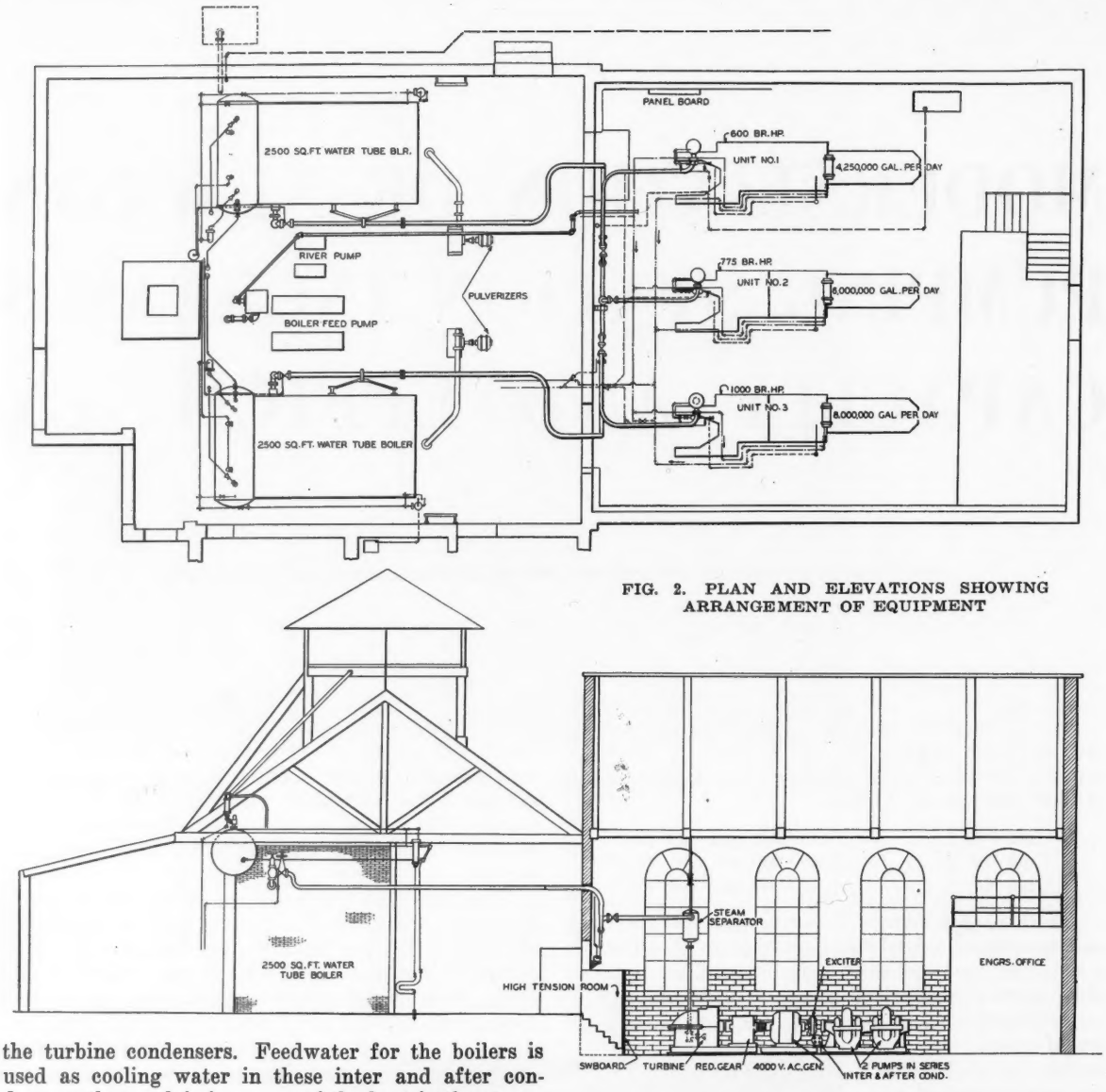


FIG. 2. PLAN AND ELEVATIONS SHOWING ARRANGEMENT OF EQUIPMENT

the turbine condensers. Feedwater for the boilers is used as cooling water in these inter and after condensers, thus reclaiming some of the heat in the steam. Schutte-Koerting water eductors evacuate the condensate, thus providing a complete condensing system without moving parts.

Complete Instrument Equipment and Switchboard Help Control the Operation of the Plant

As may be seen from the photographs, the machines are installed parallel to each other and despite the difference in size present practically the same appearance. In the center of the room may be seen the switchboard, set in a recess in the tile wall and with the high voltage apparatus in a room directly in back. This board was supplied by the Electric Mach. Mfg. Co. and consists of five panels, three main generator panels, one feeder panel to the reservation district where the well pumps are located and finally a feeder panel for station service. A synchronoscope is mounted on a swinging panel at the right of the board. This switchboard is of most modern design, having square cased meters, and remote, electrically controlled oil circuit breakers.

Another panel in the pump room contains the instruments for the turbine driven pump units. These instruments consist of the usual steam pressure gages for main steam and bleeder steam respectively, a vacuum gage, an absolute pressure gage, water discharge pressure gage, a recording static pressure gage and a suction vacuum gage. These with the exception of the Crosley recording gage are Ashton instruments. A Frahm vibration type frequency meter is mounted directly on each of the three turbines.

Interior Finish Adds to Attractive Appearance

So much for the turbine-pump room, though a word or two here may be said of its general appearance. It is finished attractively, the walls being surfaced with buff acoustical plaster and with a mottled buff tile wainscoting extending to a height of approximately ten feet from the floor. The latter is red tile. The entire room possesses an atmosphere of brightness and cleanliness that contrasts greatly with that which existed before the modernization took place.

The new boiler plant consists of two 2500 sq. ft.

Erie City cross drum, straight tube, water tube boilers equipped with Foster Wheeler superheaters giving from 125 to 175 deg. of superheat depending upon the load, and fired by the Riley Atrita system of pulverized coal. The operating steam pressure is 240 lb. and the total temperature of the steam is 550 deg. which is 200 deg. higher than the steam temperature of the original plant. The boilers are set 10½ ft. high and are supported on steel columns independent of the building. These columns were made heavy enough to carry the overhead bunkers and the feedwater heater as well as the access galleries at the sides and top of the boiler. The entire floor space was thus left clear for equipment.

In determining the size of boiler equipment the steam demand of the largest of the three turbine driven pumps when operating under full head and with full electrical load on the generator was the deciding factor. Each of the two new boilers has capacity for this load so that only one boiler is in operation at any one time, the second being in reserve. The full steam load on the boiler including the main turbine and all auxiliaries is between 9000 and 10,000 lb. per hr.

The original square brick chimney, 105 ft. high, was not changed and is being used with complete success for the new boilers. The limited draft from the low chimney required careful consideration, however, in working out the design. No attempt was made to secure high overload capacity from the boilers. For one reason, the available draft from the chimney is insufficient for high ratings, and also the small boilers and furnaces used are best suited to conservative operating rates. When supplying the maximum steam demand of 10,000 lb. per hr., the boiler operates at 135 per cent of rated capacity.

For firing these boilers, two Riley Atrita Unit pulverizers are provided, one for each boiler, but so interconnected that either can be used for each boiler. These machines are motor driven and are located on the operating floor in the center of the room in front of the boilers. Pulverized coal was chosen for this installation in preference to oil on the basis of cost. Had oil been available at a price comparable with coal, oil would have been selected but since this was not the case, coal was chosen. The station has a large covered coal pocket dug into the side of a hill back of the plant so that the coal is unloaded from an overhead gallery. This is the same arrangement that had prevailed before except that now a platform scale is installed on the gallery for weighing the coal as it is received.

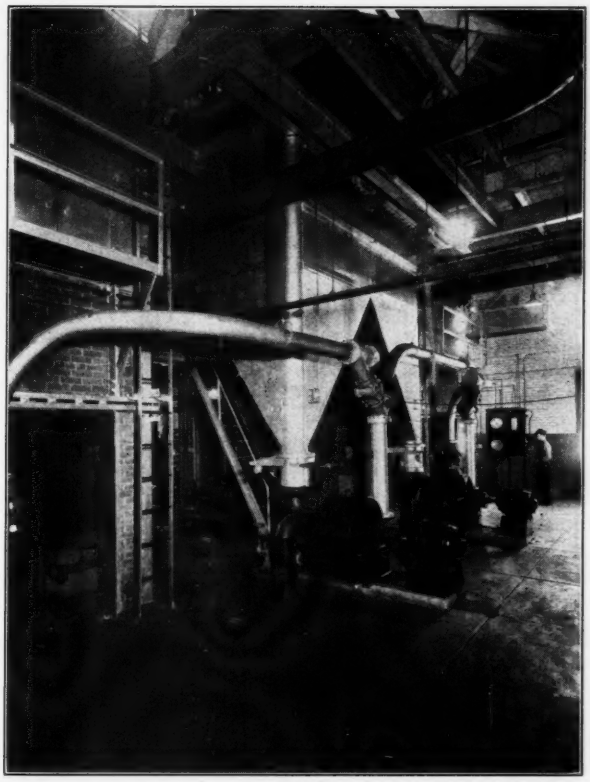


FIG. 3. THE TWO NEW 250 HP. WATER TUBE BOILERS TOGETHER WITH THE UNIT PULVERIZERS. THE FEED PUMPS CAN BE SEEN IN THE MIDDLE DISTANCE UNDERNEATH THE FEEDWATER GALLERY

Coal from this storage pocket is wheeled to a coal hopper near the boiler room and after passing through a grizzly to exclude lumps, is raised to the upper part of the coal pocket by a bucket elevator which discharges to a screw conveyor. This screw conveyor in turn passes horizontally into the upper part of the boiler room where it discharges into a small hopper located above a Richardson coal scale, in which the coal is automatically weighed and discharged into the hoppers below. The coal conveying system is all of Jeffrey manufacture. There is a separate storage hopper above each pulverizer, below the scale. To prevent overfilling

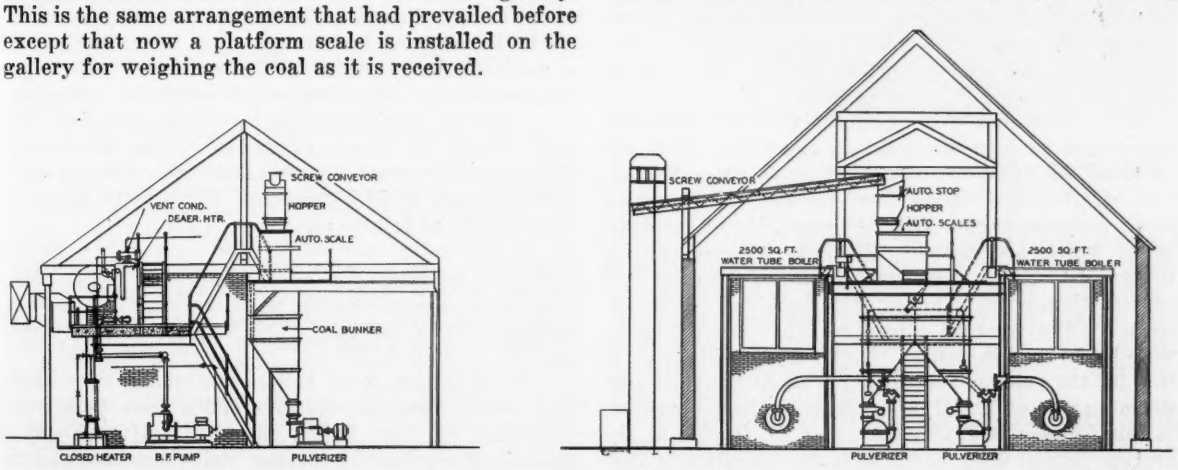


FIG. 4. SIDE AND FRONT ELEVATIONS OF THE BOILER ROOM SHOWING FEEDWATER HEATING AND FUEL EQUIPMENT

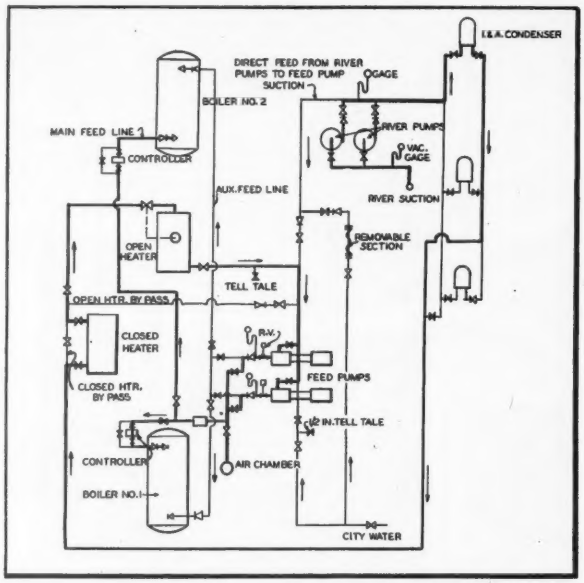


FIG. 5. DIAGRAM OF THE BOILER FEEDWATER PUMPING AND HEATING ARRANGEMENT

the hopper above the scale, an automatic arrangement is provided so that when the hopper is nearly full the starter on the conveyor motor is tripped out and the entire conveying system shut down. This automatic feature is made use of three times a day by the different shift firemen in their regular filling of the bunkers.

After being weighed, the coal is diverted by a flap damper into either of two storage bunkers. The shape of these bunkers was determined after careful study so that there would be a minimum of trouble due to the coal arching across which it has a great tendency to do, especially when wet. The bunkers as built have two adjacent sides vertical from top to bottom and the other two sides slope at 60 deg. from the horizontal. The corner between the vertical sides is rounded to a radius of 6 in. exactly conforming to the shape of the gate at the bottom. The results with these bunkers have fully justified the merits of this design.

After being pulverized the coal is delivered directly to the burners, which are mounted in the front wall of the furnaces. In addition to the powdered coal burners, each boiler is fitted with an oil burner capable of supporting a 4000 lb. per hr. load. This oil burning system is used for starting up and would also serve as an emergency method of firing in case of need.

The boilers are well equipped with all necessary accessories for insuring efficient operation. They are provided with CO_2 recorders, uptake pyrometers, multiple draft gages, steam flow meters and recording steam pressure gages. With the exception of the draft gages which are Ellison, all these instruments are Brown instruments. The furnaces are of the solid wall construction, without air or water cooling and amply large for the expected capacities. They are 7 ft. 6 in. wide by 14 ft. 2 in. long with an average height of 10 ft. 0 in., the volume being 1060 cu. ft. At the maximum steaming rate of 10,000 lb. per hour the heat liberation in this furnace is 12,500 B.t.u. per cu. ft. and at the average rate of 6000 lb. per hour the liberation is 7600 B.t.u. Each boiler is equipped with Diamond, valve-in-head soot blowers, Ashton safety valves, Yarway water columns and Yarway blow-off valves. The valves throughout the plant generally are Walworth valves.

The feedwater supply and heating system at this plant is quite interesting. A diagram of the connections is shown in Fig. 5. Boiler feedwater is drawn directly from the river by small centrifugal pumps through the intake which was used for the same purpose by the original plant. The pumps are De Laval units rated at 40 g.p.m., 75 ft. head, driven by electric motors.

After leaving the pumps the water passes through the inter and after condensers of the steam jet air pumps where it reclaims several degrees of heat which would otherwise be lost, and then passes on to a Riley closed feedwater heater. This heater receives exhaust steam from the boiler feed pumps. In this heater the water picks up from 60 to 70 deg. From the closed heater the water goes to an open Worthington deaerating heater and then by gravity to the boiler feed pumps. The deaerating heater is supplied with steam from the third stage of the main turbines. The pressure of the extraction line varies from atmosphere up to 5 or 6 lb. depending upon which turbine is running and the value of the load. With this arrangement of feed heating, the feedwater temperature entering the boiler ranges from 210 to 240 deg.

Piping System Simple

Two boiler feed pumps are provided. These are Dean, duplex, outside end packed plunger pumps, 6 by 3 by 10 in. and are located on the operating floor between the boilers. Here also are located the two river pumps which supply the boiler water. The level of the water in the boilers is controlled by Stets feed water controllers.

The arrangement of equipment in the boiler room and the piping is simple and convenient. A 4-in. superheated steam line extends from each boiler into the turbine room where they connect to form a loop. Three inch leads from this loop feed the turbines. All stop valves are conveniently accessible from the top of the switchboard enclosure, as may be seen in the photograph.

From this brief description, it will be evident that this pumping plant has been thoroughly modernized and that no effort has been spared to produce a plant that is both efficient and reliable. As pointed out by D. D. Eames, who had charge of all boiler equipment, a controlling feature in the design of the boiler room was to produce something which would be in keeping with the high grade pumping equipment installed. The new boilers and firing system have given entire satisfaction and during the acceptance tests gave an average efficiency of 75.7 per cent. Three tests were run with results as follows:

No. of Test	1	2	3
Boiler hp. developed	183	229	282
Per cent of boiler rating	73.2	91.5	112
Equivalent evaporation per hr. lb.	6310	7910	9810
Equivalent evap. per lb. of coal as fired	10.5	11.7	11.0
Efficiency of unit, per cent	73.2	79.2	74.6
Average efficiency, 3 tests	....	75.7	....

The operation of the boilers continually shows high CO_2, low exit gas temperatures, and a clean stack, three criterions of high boiler efficiency. After about 6 months of service the furnace walls show no spalling or other signs of failure. The new equipment is being operated by exactly the same men who formerly shov-

elled coal in the old plant and there has been comparatively little to criticise in the way they have taken hold of the new ideas involved in the operation of a pulverized coal plant.

Principal Equipment in the Needham St. Pumping Station, Newton, Mass.

GENERAL

Type Plant.....City Water Pumping Station
Location.....City of Newton, Massachusetts
Engineers { Weston and Sampson, Consulting Engineers of Boston
D. D. Eames, Consulting mechanical engineer, Boston
Contractors for Pumping and General Equipment.....
.....Turbine Equipment Co., of New England

BOILERS AND AUXILIARIES

Boilers—Erie City Iron Works, 2, 2502 sq. ft. cross drum, straight tube boilers, set 10½ ft. high from floor to bottom of front header. Operating pressure 240 lb. gage. Designed to supply maximum steam requirements of 10,000 lb. per hr. when operating at 135 per cent of rating. Furnace, solid wall type fired by pulverized coal.

Superheaters—Foster Wheeler Corp. 1056 sq. ft. convection. Designed to provide an average total steam temperature of 550 deg. or about 150 deg. of superheat.

Draft—105 ft. Chimney.

Fuel Burning System—Riley Stoker Corp., Atritas, 2 units each with a capacity of 1500 lb. per hour. Driven by 20-hp. General Electric motors.

Fuel—Low volatile bituminous, nut and slack, about 14,000 B.t.u. per lb.

Boiler Feed Pumps—Dean Bros. Co., 2 direct acting duplex steam pumps, fitted with Ruggles-Klingemann Mfg. Co. feed pump governor.

River Water Pumps—De Laval; type, centrifugal; capacity 40 G.P.M. vs. 75 ft. head 2 H.P. General Electric motors.

Coal Scale—Richardson Scale Co. automatic recording type.

Coal Conveying Equipment—Jeffrey Mfg. Co.—Vertical bucket elevator, screw conveyor, etc.

Coal Hoppers—International Engineering Works, Inc.

Feedwater Heaters—Griscom-Russell Co. Reilly closed heater, Worthington Pump & Mach'y Corp. deaerating heater.

Soot Blowers—Diamond Power Specialty Corp. Diamond Valve-in-head soot blowers.

Safety Valves—Ashton Valve Co.—Two 3-in. safety valves each boiler drum, 1—2" valve each superheater.

Water Columns—Yarnall-Waring Co.

Blow-off Valves—Yarnall-Waring Co.

Feedwater Regulators—Stets Co.

Instruments—Steam gage pressure gages, vacuum gages, water discharge pressure gages and suction pressure gages, Ashton Valve Co., recording static pressure gage, Crosby Steam Gage & Valve Co., CO_2 recorders, Uptake pyrometers, steam flow meters, recording steam pressure gage, Brown Instrument Co. Draft gages, Ellison Draft Gage Co., Venturi Meter, Builders Iron Foundry.

Valves and Fittings—Walworth Co.

TURBINE AND ELECTRICAL EQUIPMENT

Turbine Pumping and Generating Units—De Laval Steam Turbine Co. and Electric Machinery Mfg. Co. 3 units as follows: 1—600 brake hp. De Laval steam turbine, 5980 r.p.m. geared down to 1200 r.p.m. 1—250 kv.a. Electric Machinery Mfg. Co. 4000 v. 60 cycle, 3 phase alternator with exciter. Two De Laval single stage centrifugal pumps connected in series to pump 2950 g.p.m. against 272 ft. head when operating at 1200 r.p.m. 1—775 brake hp. De Laval steam turbine, 6060 r.p.m. geared to 1200 r.p.m. Same size generator as above unit. Two centrifugal pumps connected in series to deliver 4175 g.p.m. against 295 ft. head at 1200 r.p.m. 1—1000 brake hp. De Laval turbine, 6060 r.p.m. geared to 1200 r.p.m. Same size generator as above. Two centrifugal pumps connected in series to deliver 5560 g.p.m. against 340 ft. head at 1200 r.p.m.

Condensers—Foster Wheeler Corp. Water Works surface condenser.

Electrical Switchboard—Electric Machinery Mfg. Co.—5 panel vertical switchboard consisting of three generator and exciter panels and two feeder panels.

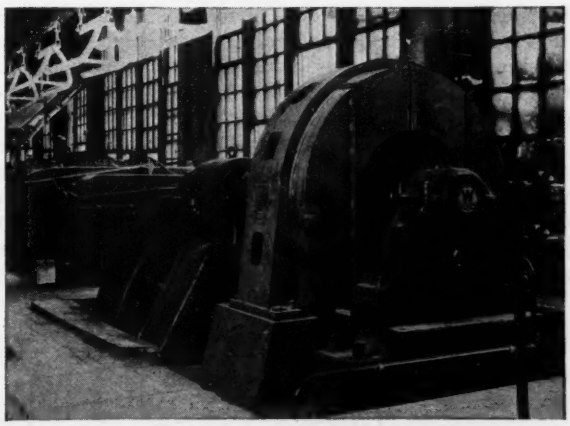
Steam Jet Air Pumps—Schutte & Koerting Co., two stage surface type inter and after condensers.

In the same way, the new pumping equipment has proved unusually satisfactory. On each unit, during the acceptance tests, the attained duty exceeded the guaranteed duty by an ample margin. The guaranteed duty of unit No. 1 in ft. lb. of useful work per 1000 lb. of steam was 168,200,200 while the attained duty was 188,013,000. Similarly, for unit No. 2, the guaranteed and attained duties were, respectively, 186,600,000 and 194,060,000 ft. lb. and on unit No. 3, 183,400,000 and 191,220,000 ft. lb. These results gave an average advantage for the three units of 6.68 per cent over the guaranteed duty.

The work of rehabilitating this plant was done under the direction of Richard H. Ellis, Water Commissioner of the City of Newton. Turbine and pump equipment was installed by the Turbine Equipment Co. of New England under supervision of Weston and Sampson, Consulting Engineers of Boston, while the boiler plant was designed by D. D. Eames, mechanical engineer of Boston. In concluding this description we wish to express our indebtedness to both Mr. Ellis and Mr. Eames and to the Turbine Equipment Co. of New England for valuable assistance in supplying data, photographs and drawings used in this article.

Quick Stopping Motor for Rubber Mill

BUILDING A one thousand-horsepower motor that can be brought from full speed to a dead stop in one and one-quarter seconds or three and a half revolutions so that the huge rolls of rubber mills will stop quickly, is the latest accomplishment of engineers of the Westinghouse Electric and Manufacturing Company. The rotating element of this motor weighs more than three tons and turns with a speed of 514 revolutions a minute. The energy required to stop this rotating mass is sufficient to lift a modern passenger elevator loaded with 12 passengers to a height of 24 stories. The unit is being furnished the Goodyear Tire and Rubber Company at Akron, Ohio. There it will drive through gears a number of huge rolls, each seven feet long and more than two feet in diameter.



WESTINGHOUSE 1,000-HP. SYNCHRONOUS MOTOR, WHICH CAN BE STOPPED IN THREE AND ONE-HALF REVOLUTIONS, INSTALLED AT THE GOODYEAR TIRE PLANT

As the plastic, crude rubber is drawn between the rolls, it travels at a speed of 19 in. a second. So the rolls must be stopped quickly in case of emergency to avoid injury to the operator.

POWER PLANT ENGINEERING April 1934

State Surface of Steam

When Applied to Substances Such as Water In Its Solid, Liquid, Gaseous and Transition Stages, Mathematical Equations of Simple Form Are Limited In Their Scope to These Individual Stages, Each One Requiring a Separate Formula, as Is Beautifully Illustrated on a Three-Axes Diagram

By
R. L. Scorah

EXPERIENCE has shown that the state of aggregation of a substance is described by the variables, pressure (p), specific volume (v), and the temperature (T). The characteristic equation or the equation of state is, therefore, of the form

$$f(p, v, T) = 0.$$

This equation is perfectly general: it expresses the fact that these three variables are related in a fixed and definite way. Whether this fixed and definite relation can be represented by a mathematical expression is quite another matter. The problem of finding such mathematical expressions has occupied some of the world's foremost minds over a long period of time.

Perhaps the first contributor to this problem was Robert Boyle, who, in 1662, demonstrated that the pressure of a gas varies inversely as the volume when the temperature is constant, a relation that is now known as Boyle's Law. Boyle himself knew that this law held only under ideal conditions such as were closely approximated by real gases at high temperatures and low pressures, while under ordinary conditions it did not correctly represent the true performance of any real gas.

In 1802, Joseph Louis Gay-Lussac found that the pressure of a gas varies directly as the temperature when the volume is constant, and this result is known as Gay-Lussac's (or Charles') Law. This relation likewise applies only under ideal conditions such as are closely approximated by real gases at high temperatures and low pressures. Such performances as condensation and freezing are completely ignored.

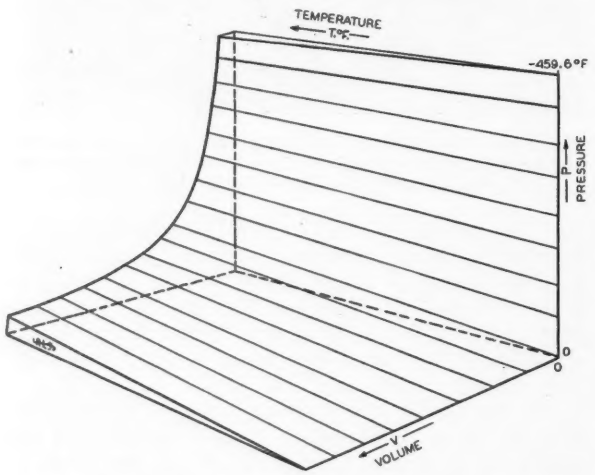


FIG. 1. THE STATE SURFACE OF A PERFECT GAS

Ideal Gas Behavior

The combination of the Laws of Boyle and Gay-Lussac yields the well known equation, $pv = RT$. No real substance is truly represented by this equation but, as in the case of the foregoing laws, it closely approximates real gases when the temperature is high and the pressure is low. Under such conditions a real gas is said to behave like a perfect gas or an ideal gas. The equation, $pv = RT$, is, then, the characteristic equation or equation of state of an imaginary substance described as a perfect gas. With the appropriate constant (R), this simple equation is extremely useful, for a great many working substances met with in practice can be very closely described by it.

By making use of the rectangular coördinates p, v, and T, the equation, $pv = RT$, describes the surface shown in Fig. 1, which is known as the characteristic surface or state surface of a perfect gas. The state surface of a real substance is not so simple.

Steam, which is perhaps the most important working substance, cannot be closely described by the above simple equation. In fact in modern practice it has become so necessary to know accurately the properties of steam that a great deal of experiment has been directed to this end. These elaborate researches have not brought to light a simple equation similar to $pv = RT$, but rather, it has proved expedient to present these results in the form of steam tables. A plotting of these data, with p, v, and T coördinates, describes the interesting state surface of steam, shown in Fig. 2. The scales of this diagram are modified to reveal clearly some of the more interesting details.

Sources of Data for Diagram

Keenan's Steam Tables provide data for those conditions ranging from 32 deg. F. to 1000 deg. F. and pressures up to 3500 lb. per sq. in. absolute. It will be observed from Fig. 2 that the surface of wet steam is defined by elements that are perpendicular to the p—T plane. This wet steam surface terminates at the critical temperature, see point A. The critical temperature may be defined as that temperature above which a substance cannot be liquefied by pressure alone. For steam this critical temperature is 706.1 deg. F. The companion pressure or the highest pressure that can produce liquefaction is the critical pres-

Visualized

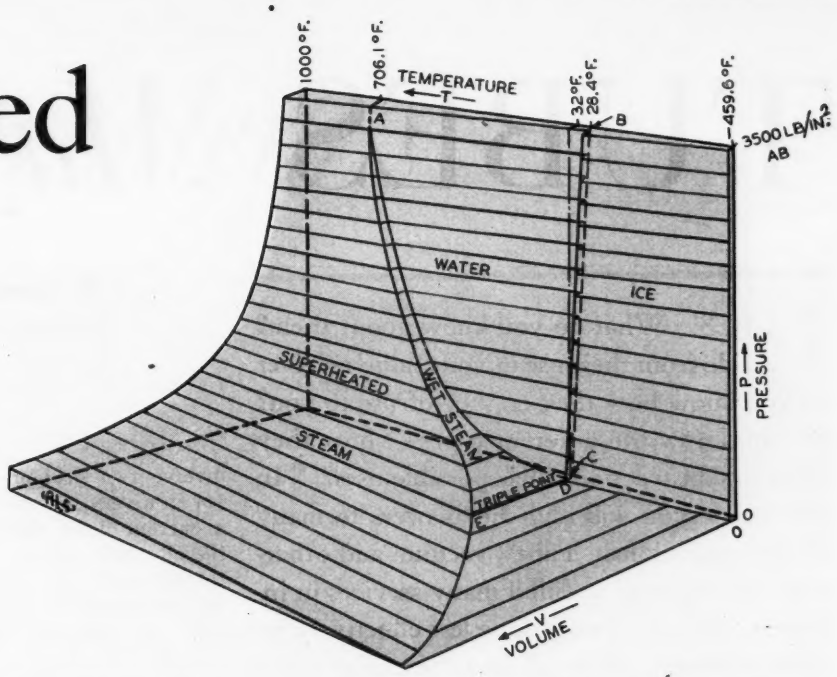


Fig. 2. The state surface of steam in various physical forms

sure, which is 3226.0 lb. per sq. in. absolute for steam. The specific volume of a substance at the critical temperature and under the critical pressure is the critical volume (the specific volumes of the liquid and vapor phases are then assumed to be equal). The critical specific volume of steam is 0.0522 cu. ft. per lb.

Water under atmospheric pressure freezes at 32 deg. F. but Bridgman[1] has shown that the freezing point falls slightly as the pressure is increased so that at 3500 lb. per sq. in. absolute water freezes at about 28.4 deg. F. (point B). The narrow surface representing mixtures of ice and water is also perpendicular to the p—T plane and is slightly convex toward the p-axis. It is also interesting that the width of this surface is not quite constant. When water freezes at atmospheric pressure, its volume as ice is greater by 9 per cent but if freezing occurs under a pressure of 3500 lb. per sq. in. absolute, this figure increases to about 9.5 per cent.

This narrow "wet ice" surface intersects the "wet steam" surface at the line CD which, when produced to E, forms the line that describes the triple point conditions. The triple point may be defined as the pressure and temperature at which the solid, liquid, and gaseous phases of a substance may coexist in equilibrium. For steam the coördinates of this point are $T = 0.0135$ deg. F. and $p = 0.0885$ lb. per sq. in. absolute, while the specific volume v may range between C and E depending on the amount of each phase existing in the mixture.

The vapor pressure of ice, described by the curve from D to the v-axis, is quite small but measurable: values may be found in the International Critical Tables. The behavior at absolute zero temperature is still rather obscure although it would seem, from modern statistical theories of matter, that a zero vapor pressure may be expected. This would cause the saturation line AE to approach the v-axis as an asymptote.

[1]Proceedings of the American Academy, 47; 440.

Diagram Visualizes Limits of Equation

With the resulting diagram in view, it is at once clear why the simple equation, $pv = RT$, cannot be made to serve as an equation of state for steam. If, however, a perfect gas surface were fitted to the coördinates of the steam surface, by appropriate adjustments of the constant R, it could be made to fit rather closely a large portion of the superheated steam area. It is in precisely these conditions, well above and away from the saturation line, that water vapor behaves very nearly like a perfect gas. In fact, it is for this same reason that the equation, $pv = RT$, can describe so well the behavior of a gas like hydrogen. Hydrogen has a state surface similar, in most respects, to that of steam except that its critical temperature is extremely low, so low that the liquid and solid phases of hydrogen are seldom encountered in practice. The hydrogen commonly met with is at or well above atmospheric temperatures and consequently, with respect to its saturation line, it is highly superheated. Such temperatures accompanied by moderate pressures, comprise the conditions necessary for a close approximation to the perfect gas equation.

Perhaps the most interesting thing about the state surface of steam is that it presents in picture form the broad aspects of the physical relationships between the three phases of water: concepts which usually lie buried in the rather dry columns of the steam tables.

Studies of this sort are of practical value wherever the substance used passes from one state to another in the cycle of operation. In the refrigerating plant a diagram of the state surface of ammonia or carbon-dioxide would aid greatly in giving a conception of the relationship which exists between volume, pressure and temperature in the various stages of the cycle. Likewise in binary vapor plants the state surface diagram will give a conception of the characteristics of mercury or other substance employed that is difficult to grasp from tables or two-dimension diagrams.

POWER PLANT ENGINEERING April 1934

TUBES *May Solve*

By Hendley N. Blackmon
Westinghouse Electric & Mfg. Co.

TUBES! What do you know about them? Aside from their use in your radio receiver do you know how they may be of use to you? Do you know the different types — how they differ in construction, their possible uses? ¶ In this article you will find the answers to many of these questions. Tubes, vacuum and otherwise, are destined to fulfill many services in industries which are now done less effectively by other methods. You will find the explanations in this article simple and informative

THOSE OF US WHO are not radio fans have not been worried much by "tubes" and "cells" until lately. But recently a whole crowd of them have appeared; tubes that see, that feel, that change a.c. to d.c., and back again; tubes that are relays, and circuit breakers; tubes that handle a hundred kilowatts. Queer words like "thermionic," "grid-glow," "Kenotron," that used to be safely shut up in the research laboratory, have broken loose, and are likely to settle down on anybody's doorstep.

Any engineer, no matter what his specialty, may find some sort of a tube useful. Perhaps others knew as little as we did about this; and possibly may be as interested as we were in what it's all about.

Tubes are doing all sorts of things, for example:

Rectifying A.C. to D.C.—Handling moderate and extremely high voltages.

Serving as Relays—Small power, controlling that a million times greater.

Acting as High Speed Circuit Breakers—Interrupting considerable amounts of power continuously without burning.

Detecting and Instantly Responding to Delicate Stimuli—Such as light and shadow, colors, heat and cold, flame or smoke, dryness and moisture, varying pressure and so forth.

Supplying Light—Of special colors or extremely rapid variation, as for stroboscopes.

Amplifying Currents—Tremendous electrical leverage.

Converting D.C. to A.C.—Any desired frequency.

Giving Variable D.C. Voltage Output from A.C.—To control motor speed, theatre lighting, etc.

The general principles, after all, are not so hard to get. There are all sorts of tubes, but all of them involve two or more electrodes sealed in a vacuum (or in a very low gas pressure). If voltage is applied, a current flows through the vacuum (or gas) from the electrode which is larger, or hotter (the cathode), to the smaller, or cooler, anode. Thus, except where the electrodes are the same size and the same temperature, all tubes pass current in one direction only; are *rectifiers.*

Either electrode may be of various shapes—a plate, a rod, a hollow cylinder, or a coating on glass. For some purposes, the tube is made with a cathode glowing hot. A convenient way to get this is to use an incandescent filament as the cathode. It could be a plate or rod heated by any other means.

With just the two cold electrodes, the amount of current depends only on the voltage between them. But various means can be added to control this flow.

With a hot cathode, you can vary its heat (used in radio and many industrial tubes).

You can make one of the electrodes out of a material that is sensitive to light—this makes a photoelectric cell or phototube.[1]

You can put a "grid" or screen between the two electrodes. Varying the voltage on the grid will control the current flow from cathode to anode. This makes the tube a relay or amplifier.

The current capacity of vacuum filled tubes is usually very slight; a little gas (about 1/1000 atmosphere) greatly increases it. Gas-filled tubes glow when passing current. Gases often used are neon—(red light), argon (purple), helium (blue-green). Some-

[1]In this type of tube the current that passes between the electrodes is proportional to the intensity of illumination.—Ed.

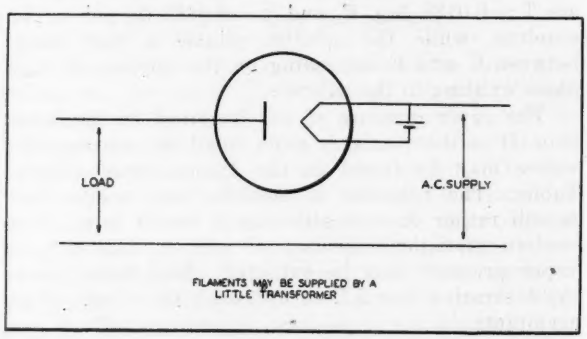


FIG. 1. TWO ELEMENT HOT CATHODE TUBE

e Your Problem

times mercury vapor is used—a drop of mercury being put in the tube, and vaporizing as it gets hot. It gives the familiar greenish glow.

For Rectifying (A.C. to D.C. Pulsating)

The Two-Element Hot Cathode Tube (Vacuum or Gas) is suitable as a rectifier. (Fig. 1.) Its bulb encloses a lamp filament and plate. The filament can be heated by either d.c. or a.c., using a convenient voltage, often 2½ or 5.

For very high voltage, with very little current, vacuum tubes are available from 100 v., 0.1 amp., to 230,000 v., 0.001 amp.—the latter being suitable for such service as Cottrell precipitators, "artificial lightning", and so forth.

If more current is wanted, gas-filled tubes can be had for 75 amp. or more, and over a voltage range from 110 to 25,000. The efficiency is good, from 90 to 95 per cent in many cases. The life is from 1000 to 10,000 hr. counting the time the filament is glowing.

Examples of this sort of tube, the Rectigon and Tungar, have been familiar for several years for charging small batteries.

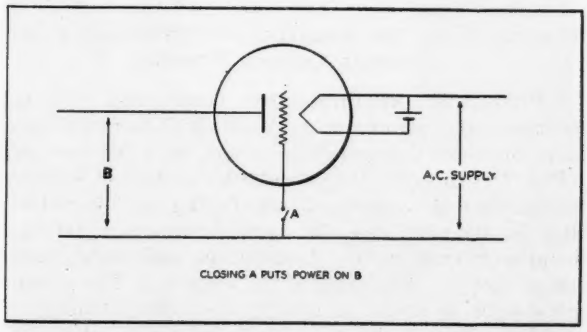


FIG. 2. THREE ELEMENT HOT FILAMENT, GRID GLOW TUBE

As a Relay

Grid-Glow Tube (Three element, hot cathode, gas). Here, between the glowing filament "cathode", and the anode, a "grid" is interposed, which controls the flow of current from cathode to anode.

No current flows from cathode to anode until the voltage on the grid is raised to approach that of the cathode. (Fig. 2.) At a certain critical point of grid voltage, the resistance between cathode and anode breaks down, and current flows.[2]

However, after the current once starts, the grid voltage has no more control over it—the current will keep on flowing indefinitely if the supply is direct current. If it is a.c., the current will flow to the end of the half-cycle, and stop (because the tube will pass current only one way).

One Relay For Two

The tube is thus a relay in which a very small grid current can control[3] quite a large plate current—a relay which "latches in" when used on direct current. (Fig. 4.)

Because so small a grid current can control so large a main current, it can often replace two ordinary relays, one controlling the other.

[2]This action applies only when there is gas in the tube. With a vacuum the current for cathode to anode will vary, depending upon the potential applied to the grid. There is no sudden "breakdown" of the cathode-anode resistance as is the case with the gas-filled tube.—Ed.

[3]Initiate, perhaps, is a better word.—Ed.

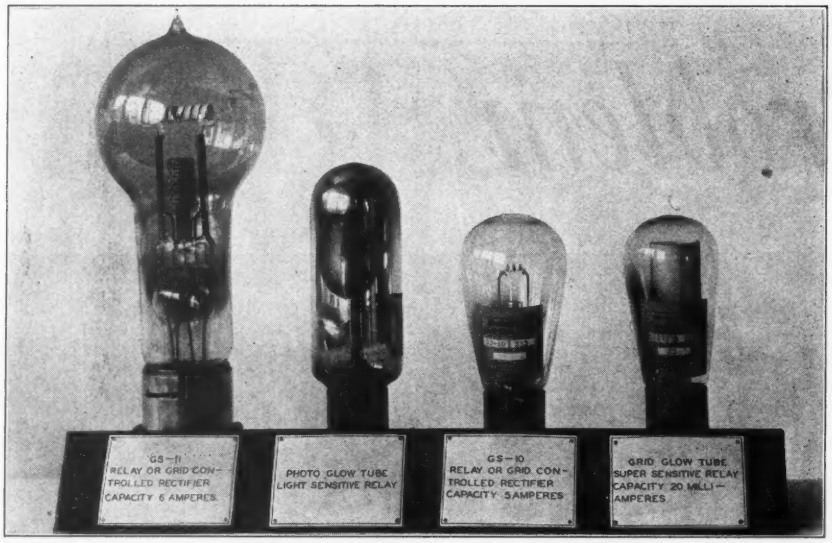


FIG. 3

GRID-GLOW TUBES

Here are shown several different types of grid-glow tubes. The first from the left is a gas filled grid controlled rectifier, with a capacity of 6 amperes. The next is a photo glow tube, also gas filled. The third is like the first except that it has a capacity of only ½ amp. The tube at the right is a cold cathode super-sensitive relay with a capacity of 20 milli-amperes.

An example of its use is in getting temperature control from a thermometer. The mercury of the thermometer makes contact with tiny sealed-in wires, closing the grid circuit. With this microscopic circuit, the tube can control several hundred watts directly. This tube-type relay is much faster than any mechanical relay, acting in one ten-millionth of a second. Its life is from 1000 to 10,000 hr., counting the time the filament is kept glowing.

Frequent High-Speed Circuit Breaker for Heavy Currents and High Voltages

Power Grid-Glow Tube (Three-element, mercury pool).—An engineer lately faced the necessity of opening a 90 amp., 220 v. inductive a.c. circuit, 400 times a minute. No ordinary switch would endure it, but the Mercury pool Grid-Glow Tube was developed for the job, and did it, without the slightest burning.

This switch is a power grid-glow tube, built for heavy current. A mercury pool serves as cathode, instead of the usual hot filament. (Fig. 4.) The current is controlled by a grid near the cathode, and the making and breaking is done in the grid circuit, which carries only a few thousandth of an ampere. With the grid circuit in the "open" position, the main current is extinguished as it passes through zero at the end of the first half cycle, and cannot re-establish itself until the grid circuit is again closed. There is no burning at all.

From what is known of mercury rectifiers, it seems that a similar mercury tube switch could be built up to 10,000 v.

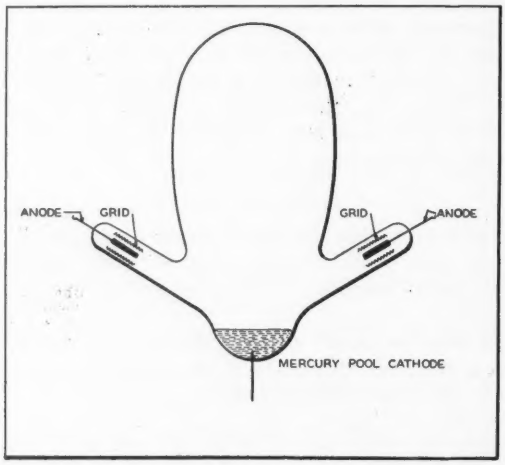


FIG. 4. THREE ELEMENT, MERCURY POOL, POWER GRID GLOW TUBE

Tube Acting on Delicate Stimuli

Grid-Glow Tube (Three element, cold cathode).—This is the device which catches burglars who get too near the silver spoons; which starts a steel mill when somebody puts his hand close to a crystal ball; which turns the fuel off in an oil-burner if the flame goes out; measures the moisture in paper; helps a micrometer to split a ten-thousandth of an inch. It is the tool of extreme sensitiveness.

Anything which affects the voltage, resistance, capacity, or reactance of the grid circuit in the slightest, can be detected and measured, since the plate current is proportional and perhaps a million times greater. (Fig. 6.) Even at heat, the plate current is very small (0.025 amp. at 440 v.), and the grid-glow tube is usually used to control another relay. Life is from 2000 hr. up (time actually carrying current). It is satisfactorily rugged, and requires no especial tenderness.

Electric Eyes Are Receiving Much Attention for Industrial Control Purposes

Phototube and Photoglow Tube (Two element, cold cathode, vacuum or gas).—Both these tubes have a cathode of light-sensitive metal, such as caesium. (Fig. 7.) In both, the impedance to flow of current varies when the amount of light falling on them varies. But in the photo-cell, the amount of current flowing is proportional to the illumination, and very small, (a matter of millionths of an ampere). The photo-glow tube acts like a relay; when the illumination reaches a critical value, the tube practically short-circuits, and passes a current a thousand times greater

than the photo-cell, a combination light cell and heavy duty relay.

A photo-glow tube will carry 0.005 to 0.10 amp. continuously, and ten times as much momentarily. It will work between 100 and 440 v., and could be built for 1000 v. Either d.c. or a.c. can be used; with a.c. the tube "resets" in one-half cycle; with d.c. when it has once "closed", the circuit stays closed until interrupted by a switch.

Where measurement of light is concerned, the photo-cell is used, with some form of amplifier, like a three-element, vacuum tube. If it is merely required to count shadows, or to distinguish between dark and light, the photo-glow is used, usually aided by a relay of some sort, like a power grid-glow tube.

The life of these cells depends on the length of time they carry full current. It should be a matter of several thousand hours.

Photo-glow tubes are so quick-acting, they can see the beginning of a flashover on a rotary or a generator, and cut the power off before the flash can develop far enough to do damage. The whole transaction is so quick that a human eye does not even see the flash, or rather, the beginning of the flash.

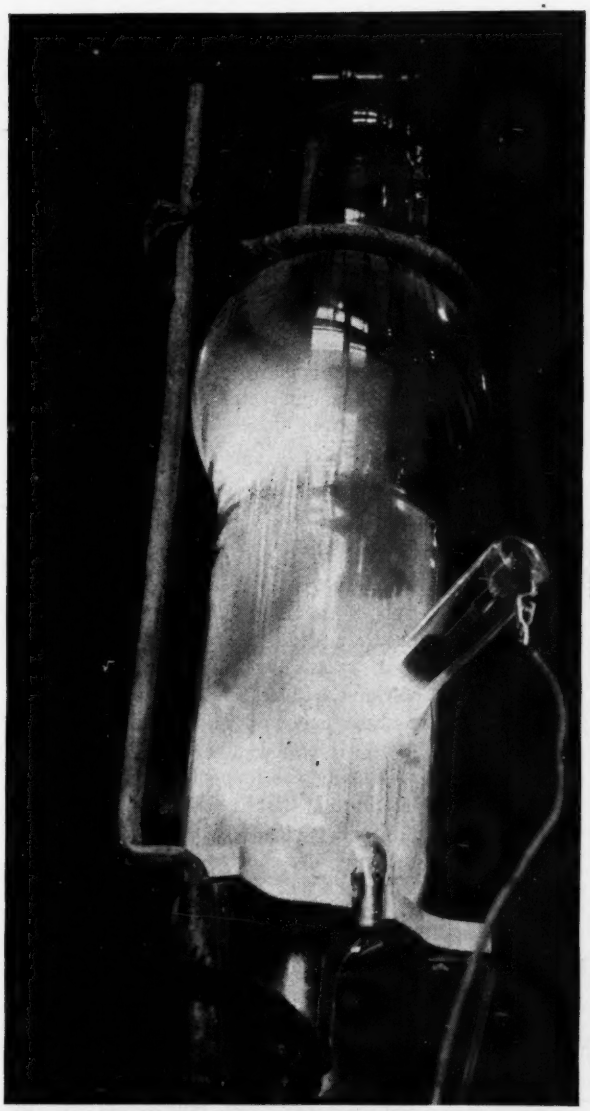


FIG. 5. HIGH POWER GRID GLOW TUBE HANDLING 900 KW. (180 AMP. AT 5000 V.)

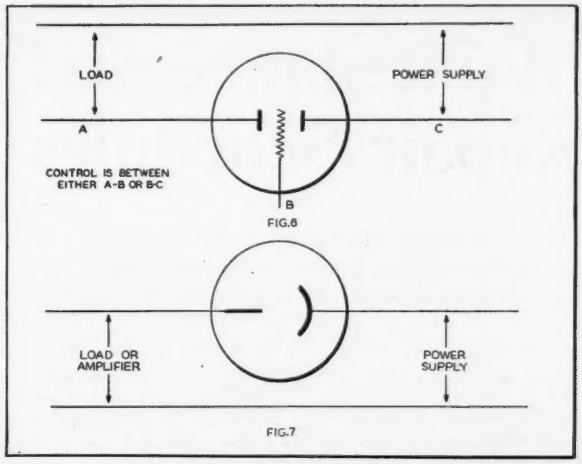


FIG. 6. THREE ELEMENT, COLD CATHODE, GRID GLOW TUBE

FIG. 7. PHOTO TUBE OR PHOTO-GLOW TUBE

Use as Lamps

Power Grid-Glow Tube (Three element, hot cathode, gas).—Like all gas-filled tubes, this glows when carrying current. The intensity of the glow increases with the size of the current, and has virtually no time lag.

In a new stroboscope, called the Stroboglow, it is used as both relay and lamp, being turned on and off by means of the grid circuit. An intense brief glow is obtained by putting a 500 amp. condenser discharge through a half amp. tube. The flash lasts but a ten-millionth of a second.

Such lamps have also been used for television, and also in a "bump meter", in which acceleration or road shocks, or acceleration of an automobile, are shown by flashes. Another use is by indicating maximum pressures in Diesel engine cylinders, to show whether any are "missing". Wherever very brief, accurately-timed flashes are needed, such a tube is suitable.

As an Amplifier

Three Element Vacuum Tube—Here the current in the plate circuit is exactly proportional to the grid voltage (which controls it), but perhaps a million times greater.[4] Even the plate current, however, is relatively very small, a small fraction of an ampere for ordinary size tubes. Very large tubes have been built, however, rating from 100 to 160 kw., but these ratings were at high voltage, and the tubes are five feet tall, and very costly.

An ordinary size tube may use 30—40 v., with practically no current, in the control (grid) circuit, and 0.04 amp. and 400 v. in the main (plate) circuit.

Such tubes can be useful in such work as metering; or, used together with some other amplifier like a three-legged reactor, they allow the control of hundreds of kilowatts of power load by a tiny radio-type rheostat.

[4]This is the type tube most used in your radio receiver.—Ed.

(To be concluded)

Maintenance and Repair Schedules

Accidents and Failure of Service Must Be Guarded Against by Keeping Equipment in Repair by Regular Inspections

TO INSURE uninterrupted service as well as achieve the highest possible efficiency, it is necessary that the equipment of a plant be kept in repair. Every piece of equipment must be repaired as soon as defects appear and, what is far more difficult and essential, wear and tear must be anticipated by careful, periodic inspection so that repairs can be scheduled in advance. Sudden and unexpected failures must be carefully avoided, because they might cause an interruption of power or result in serious accidents.

Large Systems

This is done in a systematic way by the Union Electric Light & Power Co., St. Louis, Mo., which must consider not only the machines in each plant but the relation of several plants on the system to each other. To maintain a high state of equipment repair and to carry out detailed periodic inspections this company has a special division of personnel known as the maintenance crew, under the plant's master mechanic. This group consists of machinists, millwrights, ironworkers, pipefitters, carpenters, brickmasons, electricians and boilermakers.

In general the major maintenance jobs are undertaken only during the period when the demand for electricity is at its lowest, which in the St. Louis district is the period from March through September. Accordingly, all maintenance jobs during this period are definitely scheduled in advance. Since there are several power plants in the Union Electric group supplying current to one general system this scheduling of maintenance is an important factor if the system is to be properly safeguarded in the matter of reserve capacity. Figure 2 is an example of inter-plant scheduling and Fig. 1 of jobs scheduled within one plant, Cahokia, both schedules being for the year 1930. The schedule clearly sets forth the time at which each job is to start, the time allotted to it, and the number of men required. A reasonably accurate estimate as to the number and class of maintenance men required to do the various jobs can thus be made ahead of time. The schedule is then closely followed and progress is verified with the schedule at the end of each week.

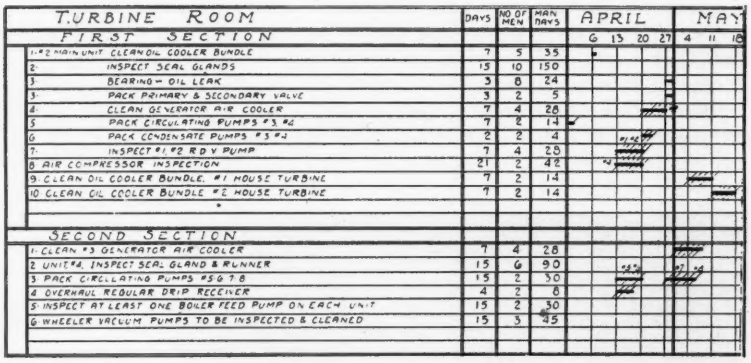

TURBINE ROOM
DAYS
NO. OF MEN
MAN DAYS
APRIL
MAY
FIRST SECTION
1. #2 MAIN UNIT CLEAN OIL COOLER BUNDLE
2. INSPECT SEAL GLANDS
3. BEARING – OIL LEAK
3. PACK PRIMARY & SECONDARY VALVE
4. CLEAN GENERATOR AIR COOLER
5. PACK CIRCULATING PUMPS #3 #4
6. PACK CONDENSATE PUMPS #3 #4
7. INSPECT #1 #2 R D V PUMP
8. AIR COMPRESSOR INSPECTION
9. CLEAN OIL COOLER BUNDLE, #1 HOUSE TURBINE
10. CLEAN OIL COOLER BUNDLE #2 HOUSE TURBINE
SECOND SECTION
1. CLEAN #3 GENERATOR AIR COOLER
2. UNIT #4 INSPECT SEAL GLAND & RUNNER
3. PACK CIRCULATING PUMPS #5 6 7 8
4. OVERHAUL REGULAR DRIP RECEIVER
5. INSPECT AT LEAST ONE BOILER FEED PUMP ON EACH UNIT
6. WHEELER VACUUM PUMPS TO BE INSPECTED & CLEANED

FIG. 1. PART OF THE SCHEDULE FOR CAHOKIA STATION
THE CROSS HATCHED AREAS INDICATE WORK COMPLETED

Figure 1 shows where No. 3 turbine at Cahokia was scheduled for repairs from the fourth week in April to the fourth week in May. While this generating unit was out of service for repairs auxiliary equipment connected to the unit was thoroughly inspected and various valves cleaned and packed, pumps inspected and overhauled, condenser cleaned and tested for leaks. If, during the inspection a part should be found that required replacement and the part cannot be obtained within the time allotted for the job, then this part will be ordered and replaced at a later date overnight or during a week-end.

A card index record of the inspections is kept up to date and added to as each scheduled inspection is made. By having these inspection records it is possible to accurately plan and schedule the next major job on this unit.

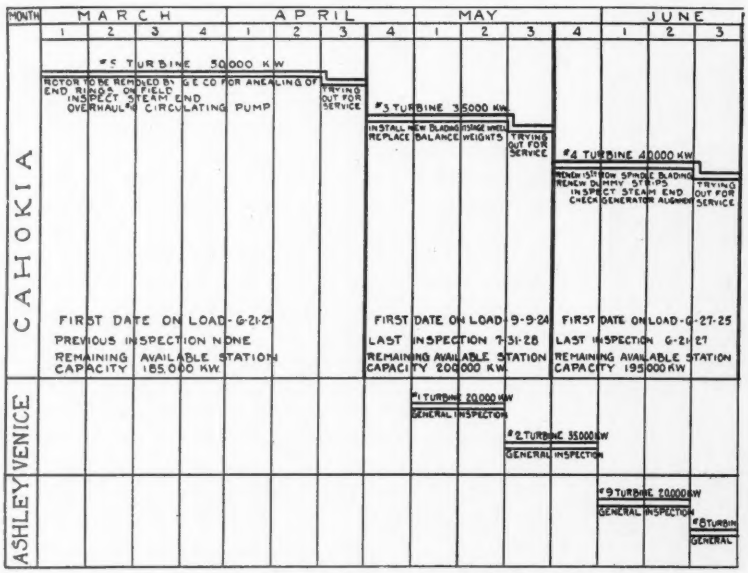


FIG. 2. INTERPLANT MAINTENANCE SCHEDULE FOR PART OF THE UNION ELEC. LIGHT & POWER CO.

Waterwheel Efficiency *of* Hydroelectric Units

A Novel Method of Increasing the Efficiency of Hydraulic Turbines by Cleaning Trash and Leaves from the Blades of the Runners

By J. F. Richmond

OPERATION and maintenance of many hydroelectric plants is taken for granted, that is, once such plants are started and placed on the line, little effort is made to improve their efficiencies in the same way that the steam plant operator constantly tries to improve the efficiency of his plant. This probably is due to the fact that many manufacturing plants located along streams make use of what water there is to assist their steam plant and regard the water power as just "something for nothing." Hydro plants, however, need attention just as a steam plant does and such attention often proves very much worth while.

Fall Is Worst Season

In the fall of the year, for instance, many leaves find their way down streams, mostly noticed by those who clean the racks located at the head of the penstock or canal leading to the wheel.

Many of these leaves as well as other trash go through the racks, and plaster themselves on the blades of the wheels and collect between the blades around the hub, which changes the stream line flow of the water through the wheel causing eddies and counter flows which decrease the efficiency of the wheel.

In the spring when the snow melts and the ice goes out, much the same thing happens, and at other times with those plants located on streams which act as sewers for the villages, much toilet paper, rags, garbage and trash passes through the wheel. A rag caught in the right place on the blades will stay there for days sometimes, reducing the efficiency from 5 to 15 per cent, depending on the amount of trash, and the location on or between the blades.

When the loss in power turned out by the wheel becomes quite noticeable, somebody is notified to clean out the wheel, which means shutting down the head gates, drawing off the water from the penstock or canal, and going down in the wheel-pit to clean out the rubbish. This costs something for time, and sometimes delay or loss of power.

Wash Out the Trash

Those plants which have their wheels operating electric generators on the same shaft, and which are connected electrically with a power company or a prime mover of their own large enough to carry the wheel at full speed with the gate shut, can clean the wheel in a few moments without disconnecting it from the system. The cost of power to drive the wheel for three or four minutes depends on the size of the wheel, but the cost is small in consideration of the benefit derived.

The method used is simple; first the field current on the generator may be reduced to the amount used when putting the generator on the line, unless more is needed for power factor correction; then the gate is shut down tight just as would be done if shutting down the wheel. The generator is thus acting as a motor and turning the wheel. Now, if the tail race can be observed, a cloud of leaves and trash will be seen in the water.

Water Flushes Debris from Blades

Operation in this manner is continued for about a minute, after which the gate is opened to about one half the amount which would be used in holding the wheel up to synchronizing speed and the wheel operated this way for another minute. This allows more water to splash against the blades especially if wicket gates are used. Since the speed of the wheel is now greater than the speed of the water, the water now strikes the blade on the opposite side from that which prevails normally. This action unfolds anything clinging to the blades and has a tendency to dislodge anything wedged between the blades.

After operating this way for a few minutes, the gate is opened to a speed slightly higher than that necessary for synchronizing to flush it. The gate is then closed and the operation repeated.

Sometimes it is necessary to repeat this operation three or four times to loosen some particularly obstinate piece of trash. If the generator comes up to the required kilowatts after the first cleaning, it shows that the blades are clean, and no more cleaning is required until the power again drops below what should be expected from the amount of water available.

During the trash season of spring and fall it is well to clean the wheel in this way twice a day, and once a day at other times, this insures getting all the wheel will do from the water available.

Ten Per Cent Gain

Since using this method at the plant of the writer, an average increase of at least ten per cent has been noted in the output of the wheel. This method was discovered while experimenting with different openings of the gate.

Now, the only time it is necessary to enter the wheel-pit is when some long piece of wood gets in which won't go through and prevents the gates opening or closing properly.

The effectiveness of this operation is most noticeable at our plant during flood times, when, after the rack is known to be thoroughly clean and there is plenty of water, the generator persists in putting out only four-fifths or so of the usual kilowatts expected. The operation of cleaning the wheel is then carried out two or three times, and when the gate is opened wide again, the meters read the full power output of the machine.

Some wheels are provided with what is called a self-cleaning device, which consists of several holes drilled through the top end of the wheel hub of a vertical unit, leading from a cavity just under the shaft stuffing-box to the openings between the blades where they join the hub. A considerable pressure of water is applied through a pipe leading to the cavity under the stuffing-box, this water passing through the holes in the hub issues with some force between the blades and is supposed to wash away any trash collected there. But, as this tends to create packing troubles around the shaft, it is not used with much pressure and consequently does little good.

POWER PLANT ENGINEERING April, 1934

Fitting the *Turbine* to the *Plant*

H. S. Hemenway, Westinghouse Industrial Turbine Engineer, Tells T.A.P.P.I. Engineers the Advantages of By-Product Power Generation and How a Turbine Is Made to Fit a Particular Condition

BECAUSE OF LARGE QUANTITIES of steam used for drying paper in rolls, the paper industry was an early user of by-product power. By-product power is realized by generating steam at a pressure higher than required in the process, and expanding it down to the process pressure through a steam turbine or other prime mover generating power. The heat of vaporization of the exhausted steam is used to carry out the process requirements, such as drying paper in the rolls. The amount of power that can be obtained in expanding steam from a higher to a lower pressure is shown in Fig. 1. Expanding 50,000 lb. of steam an hour from 400 lb. throttle pressure to 100 lb. back pressure gives 1250 kw. of power; from 800 lb. initial to 100 lb., gives 1850 kw.; and if a throttle pressure of 1200 lb. is used 2250 kw. of by-product power results.

Because of the small increase in amount of heat required to produce steam at some higher pressure, as 1200 lb., instead of at 200 lb., new steam generating equipment is frequently justified on the basis of the increased efficiencies that can be realized in up-to-date generating equipment. As the increase in heat required is only 10 per cent for the extreme range of 1200 lb., 200 deg. F. sup. as compared to 200 lb., 100 deg. F. sup., the increased efficiency of the new equipment may result in generating the steam at the higher pressure with even less coal than was used at the power pressure. In this case the power obtained in expanding the steam in the turbine to the lower pressure is only subject to the capital cost of the new equipment.

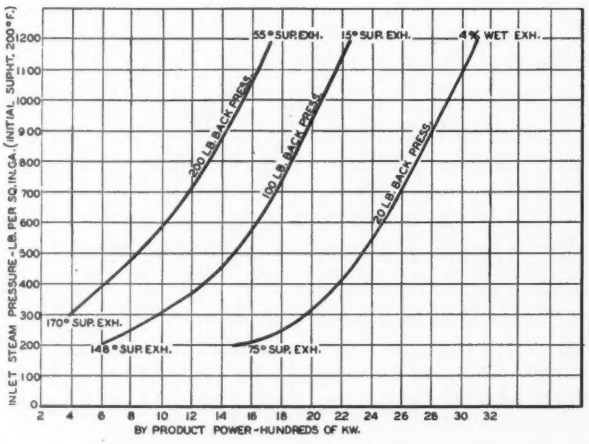

INLET STEAM PRESSURE - LB. PER SQ. IN. GA. (INITIAL SUPHT. 200° F.)
55° SUP. EXH.
15° SUP. EXH.
4% WET EXH.
200 LB. BACK PRESS.
100 LB. BACK PRESS.
20 LB. BACK PRESS.
170° SUP. EXH.
148° SUP. EXH.
75° SUP. EXH.
BY PRODUCT POWER - HUNDREDS OF KW.

FIG. 1. POWER OBTAINED FROM 50,000 LB. PER HR. OF STEAM BEFORE PASSING TO LOW PRESSURE STEAM HEADER

Many such installations have been made in the paper industry showing that there is a general appreciation of the advantages to be gained. But a turbine so installed may serve some other plant requirement so well that the power obtained comes nearer still to satisfying the urge to get something for nothing. The problem of steam pressure control, temperature control, frequency control, or load control is frequently of major importance. Turbines have been successfully applied to cover each of these requirements, sometimes two kinds of control being obtained on one machine.

Turbines Made to Fit

A turbine expanding steam from a higher pressure to a lower pressure may have a pressure regulator on the turbine exhaust. The turbine will then carry just enough load to satisfy the demand for steam at the exhaust pressure. Another type of control of pressure at one point is the bleeder turbine, which bleeds out sufficient steam to maintain the desired pressure. In addition to the steam bled, sufficient steam is expanded to a lower pressure to generate the desired power. This turbine is thus responsive to load as well as pressure.

Another type of one point pressure control is the throttle pressure regulator. This finds application where a higher pressure boiler has been installed to supplement a lower pressure system. It allows the maximum power to be generated in the new high pressure generating equipment of higher efficiency. With this control the turbine passes more steam and carries a higher load where the throttle pressure increases because of a surplus of high pressure steam. An application of such controls is shown in Fig. 2.

The pressure may be controlled in two different lines by means of a back pressure bleeder turbine. In this case the turbine bleeds at one pressure and exhausts at a lower pressure, both under pressure control. The load carried is strictly dependent on the demand for steam at the two pressures. Other prime movers on the line determine the electrical frequency of the system.

A double bleeder turbine may send steam out to two lines at two different pressures, each under pressure control. Sufficient steam is then expanded to a still lower pressure, generally that of a condenser, to carry the required load. Such a turbine may main-

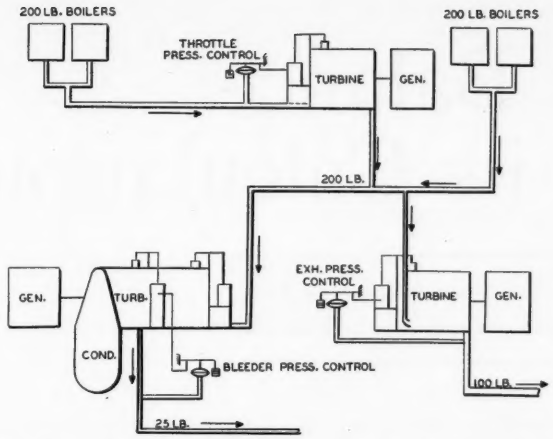


FIG. 2. TURBINES CONTROLLING STEAM PRESSURE AT ONE POINT

tain the system electrical frequency as well as supply steam at the two pressures.

Turbines frequently exhaust to a water heater where it is desired to maintain a constant water outlet temperature with variable amount of water flow. This may be accomplished by having a temperature control element on the water outlet act on the turbine governor. The more usual way is to have a pressure regulator on the water heater, set for a pressure corresponding to the temperature desired.

A recent installation of this type, shown by Fig. 3, was made on a 4000-kw. turbine taking steam at 400 lb., 200 deg. F. sup. and bleeding to the older boiler line at 125 lb. The turbine exhausted to a water heater under control of a pressure regulator at 10 lb. abs. to maintain the water outlet of 190 deg. F.

This pressure regulator is adjustable for pressures of 2½ lb. abs. to 2½ lb. ga. to suit various water temperatures that may be required. The regulator controls the opening of the turbine valves at the 125 lb. point to pass just the required steam from that pressure to the water heater. The amount of steam bled at 125 lb. varies with the load and with the amount of steam required for water heating.

In many paper mills, particularly those using sectional paper machine drive, it is essential to hold the frequency within close limits. In order to obtain stability of turbine governing the usual practice is to make the speed variation from no load to full load 4 to 5 per cent. A governor with no speed variation between no load and full load would not be stable, and would not hold a steady frequency. A governor speed compensator has been developed combining the stability of the usual turbine governor with the characteristics of holding the same frequency at all loads. This it does by bringing the frequency back to the mean value after any load change.

This speed compensator may be applied to any condensing, non-condensing, or bleeder turbine. Generally only one turbine on the system should be so equipped and this must be of sufficient capacity to carry all of the load swings. Figure 4 shows a turbine which controls the pressure at two points and also has a speed compensator to maintain the electrical system frequency.

The power produced is determined by the demands

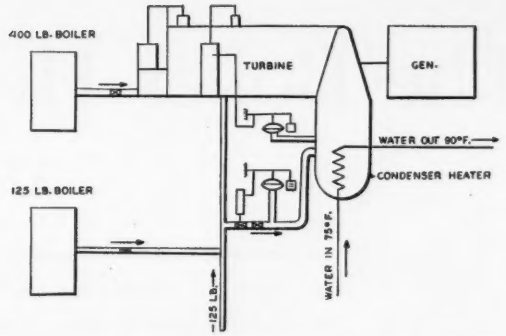


FIG. 3. TURBINES SUPPLEMENTING LOW PRESSURE BOILER SYSTEM AND EXHAUSTING TO WATER HEATER

for steam at the two pressures and such a unit may be tied-in electrically with other machines in the same plant, or as is more frequent, tied-in with an outside line.

Speed and Pressure Regulation Combined

In case of failure of the outside power source, the bleeder turbine will be overloaded, and fail to maintain frequency, unless some means is used to prevent this. At one installation an electrical pilot switch is installed in the incoming power line so that in the event of failure of the outside power source, the turbine is disconnected from the board and the circuit breakers on all but the essential load, viz., paper machine drive and its auxiliaries, are opened. This brings the total load within the capacity of the turbine. The pilot switch also energizes a solenoid on the turbine automatic back-pressure control change-over valve, which shifts the turbine from back-pressure bleeder control, floating on the line, to bleeder speed-responsive control, maintaining the system frequency on the essential load. After this change-over, the frequency is held within close limits by means of the governor speed compensator.

Plants developing their own power frequently find it desirable to limit the power demand taken from a hydro unit or from an outside line. This may be done by arranging some turbine in their plant to operate in response to a load control device. At one plant such a load control, consisting of a watt-meter element, operates the speed changers on two of their four turbines to keep the load carried by the tie-line substantially constant. Any tendency for the tie-line to pick up load causes the load control to set on the turbine governor to increase the turbine load, this reducing the tie-line load to the desired value.

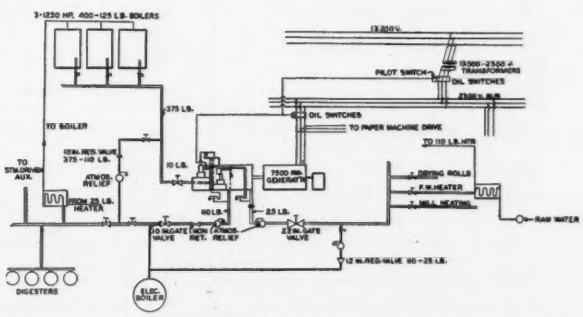


FIG. 4. TURBINE CONTROLLING TWO PRESSURES AND ALSO ELECTRICAL SYSTEM FREQUENCY

The Boiler Heat Balance and its Calculation

Part II. Charts for the Solution of Heat Balance Problems Based Upon Average Coal Analysis. By Albert E. Canfield*

USING THE CONSTITUENT percentage curve, Fig. 1, as a basis, a set of typical ultimate coal analyses were prepared for coals between 7,000 and 14,000 B.t.u. per lb., in steps of 1,000 B.t.u., as shown in Table I. From these average analyses, a hydrogen loss chart was designed for the different B.t.u. value coals with varying exit gas temperatures as shown in Fig. 2; and a dry gas loss chart for the different coals with varying gas temperatures and excess air or CO_2 percentages, was designed, as shown in Fig. 3.

While an ultimate coal analysis is required for hydrogen and dry gas loss determination, the moisture loss can be computed directly from the percentage of moisture usually appearing in the proximate analysis. For this reason, Fig. 4 is designed for obtaining the loss from a known percentage of moisture at final temperatures from 200 to 700 deg. F. and for coals of calorific values varying from 7,000 to 14,000 B.t.u.

We have the charts Fig. 2 and Fig. 3 for obtaining dry gas and hydrogen losses under known or assumed operating conditions, for coals of different calorific values. If we assume moisture percentages as indicated in Table I; and if we compute the moisture loss for the different coals at the various exit gas temperatures; and combine this loss with the dry gas and hydrogen losses for the same conditions, we have all the determinable losses, having as variables the calorific value of the coal, CO_2 percentage, and final gas temperature. By subtracting the sum of these determinable losses from 100 per cent, we can construct a chart showing maximum theoretical efficiencies. Fig. 5 is designed in this manner. From this chart, then, it is possible to read directly, the combined boiler and furnace efficiency that would be obtained in operation, assuming complete combustion of the fuel and neglecting radiation and unaccountable losses. By assuming these indeterminable losses, and subtracting their sum from the efficiency as read from the chart, the expected operating efficiency can be obtained.

TABLE I—AVERAGE ULTIMATE ANALYSES AS RECEIVED

Coal, B.t.u.	7,000	9,000	10,000	11,000	12,000	13,000	14,000
Carbon, %	40.8	52.3	56.3	60.7	66.8	73.0	79.1
Hydrogen, %	2.8	3.4	3.8	4.2	4.5	4.6	4.6
Oxygen, %	10.6	10.0	9.7	8.7	8.5	5.1	3.7
Nitrogen, %	.7	1.0	.9	1.1	1.3	1.4	1.3
Sulphur, %	.9	.7	2.5	3.3	1.7	1.8	1.3
Ash, %	8.2	12.9	10.9	10.1	7.3	9.2	7.3
Moisture, %	36.0	18.8	15.9	11.9	9.9	4.9	2.7

*Engineering Department, Strong-Scott Mfg. Co., Minneapolis, Minn. Part I appeared in the March issue, page 130.

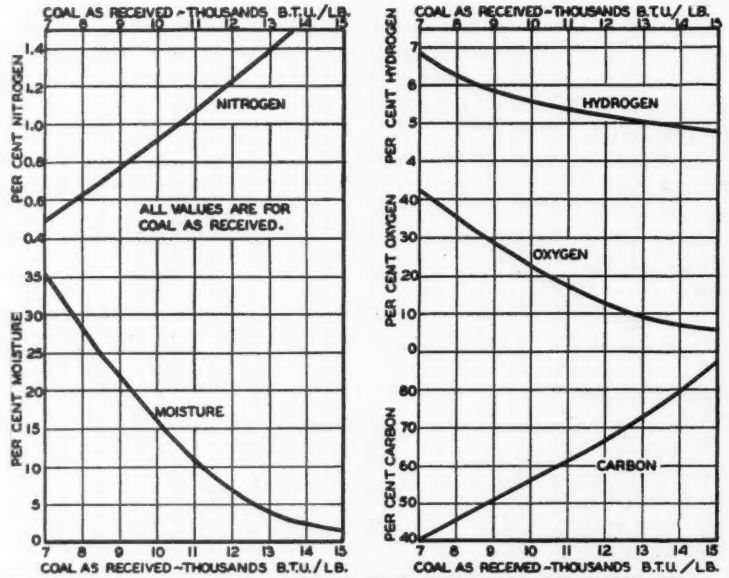


FIG. 1. DATA FOR DETERMINING THE ULTIMATE ANALYSIS OF A COAL FROM THE HEAT CONTENT

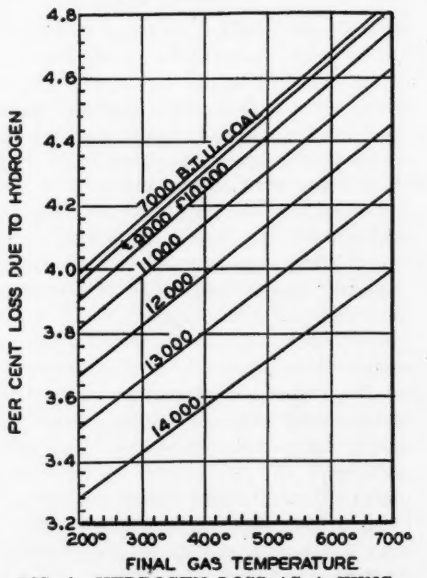


FIG. 2. HYDROGEN LOSS AS A FUNCTION OF GAS TEMPERATURE

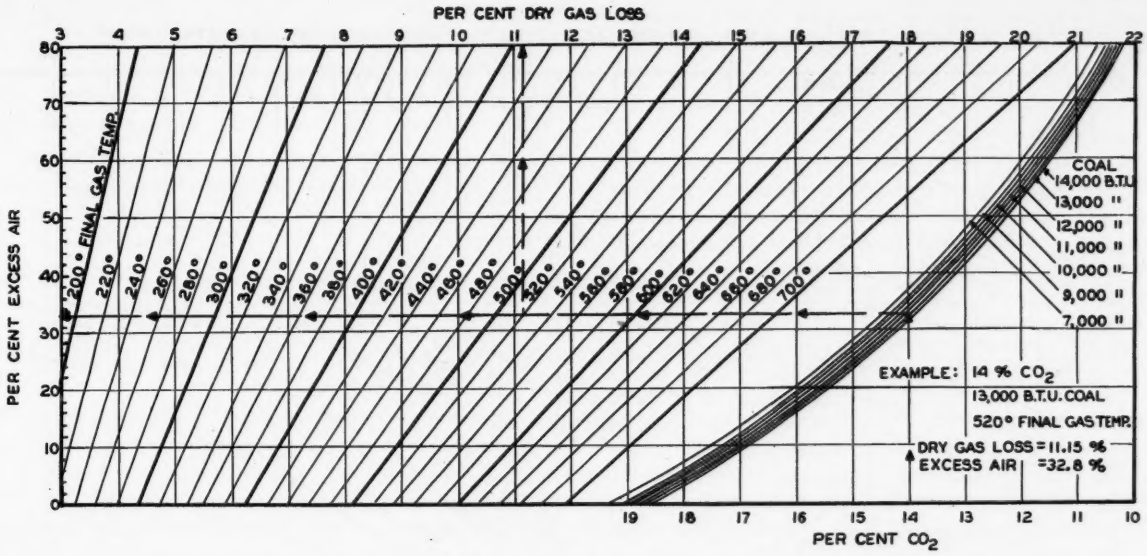


FIG. 3. DETERMINATION OF THE DRY GAS LOSS FROM THE CO_2 TEST READING

Conversely, knowing the boiler or furnace efficiency from an operating test, the sum of the indeterminable losses can be ascertained by subtracting this efficiency from the theoretical efficiency taken from Fig. 5.

Use of Fig. 5 for determining efficiencies will usually yield results within limits of a fraction of one per cent. This is especially true when dealing with coals having a heating value in excess of 12,000 B.t.u. In general, the higher the heating value of the coal, the less the magnitude of the error. Efficiencies when using coal of low calorific value having ash and moisture contents approximating those shown in Table I, however, may be read directly from the graph, and the results obtained be still within the realm of reasonable tolerance.

As a rule, a high inherent moisture content in coal is the principal cause of its low calorific value. The average ash content, as will be noted in Table 1, remains fairly constant throughout the range of fuels shown. Exceptions to this condition exist in coals having low calorific values by virtue of an abnormally high ash content, and in these cases the percentage of moisture is usually below normal, even when comparison is made on an ash-free basis. When fuels of this nature are to be considered, it is desirable to use Figs. 2, 3, and 4 for obtaining the determinable losses, and subtract their sum from 100 per cent to arrive at the theoretical maximum efficiency. The use of Fig. 5 in these cases would result in an appreciable error due to an exaggerated moisture loss.

It will further be found that with high ash coals, the dry gas loss as determined by Fig. 2 will be less than the computed value. A compensating factor, however, exists in the fact that the hydrogen loss as read from Fig. 3 will be greater than the computed loss, owing to the relatively high available hydrogen content characteristic of high ash coals. Accordingly, the sum of the losses as read from Figs. 2, 3, and 4, will agree within a reasonable tolerance to the sum of computed losses.

For the purpose of comparing the results obtained by computation and by the use of the charts in the preparation of a heat balance, the following analysis has been prepared for two Western coals of similar calorific value, but of widely different ash and moisture proportions. Neither of these coals are similar in their constituent proportions to the "average" coals shown in Table 1, and their analyses represent, probably, as great a divergence from each other as may be met in practice. The problem will be to determine the expected boiler and furnace efficiency with these coals at 300 and 700 deg. F. exit gas temperature, fuel and air temperatures at 70 deg. F., CO_2 to be 14 per cent, and a total unaccountable loss of 4 per cent.

Ultimate analysis of these two coals is as follows:

	COAL NO. 1		COAL NO. 2	
	As Rec'd.	Dry	As Rec'd.	Dry
Carbon, %	54.99	71.04	52.77	56.04
Hydrogen, %	6.21	4.78	4.80	4.41
Oxygen, %	33.97	17.95	14.28	9.65
Nitrogen, %	.94	1.21	1.30	1.38
Sulphur, %	.64	.83	.47	.50
Ash, %	3.25	4.19	26.38	28.02
Total %	100.00	100.00	100.00	100.00
% moisture	22.57	.....	5.84	.....
B.t.u. per pound	9557	12343	9529	10119

By computation, the following data is obtained:

	COAL No. 1		COAL No. 2	
Computed dry gas weight at 14% CO_2 per pound dry coal	12.95 lb.		10.19 lb.	
COMPUTED HEAT BALANCE (at deg. F.)	300	700	300	700
Dry gas loss %	5.80	15.87	5.57	15.24
Hydrogen loss %	4.03	4.70	4.53	5.27
Moisture loss %	2.73	3.18	.71	.83
Total accountable losses	12.56	23.75	10.81	21.34
Assumed unaccountable losses, %	4.00	4.00	4.00	4.00
Total losses, %	16.56	27.75	14.81	25.34
Combined boiler and furnace eff., %	83.44	72.25	85.19	74.66
Total, %	100.00	100.00	100.00	100.00

In comparison with the above results obtained srtictly by computation, the efficiency as obtained from Fig. 5 for either coal follows:

Final Gas Temperature	300°	700°
Theoretical efficiency (Fig. 5)	87.9%	77.0%
Assumed unaccountable losses	4.0	4.0
Efficiency, by difference	83.9%	73.0%

The difference between the computed efficiencies

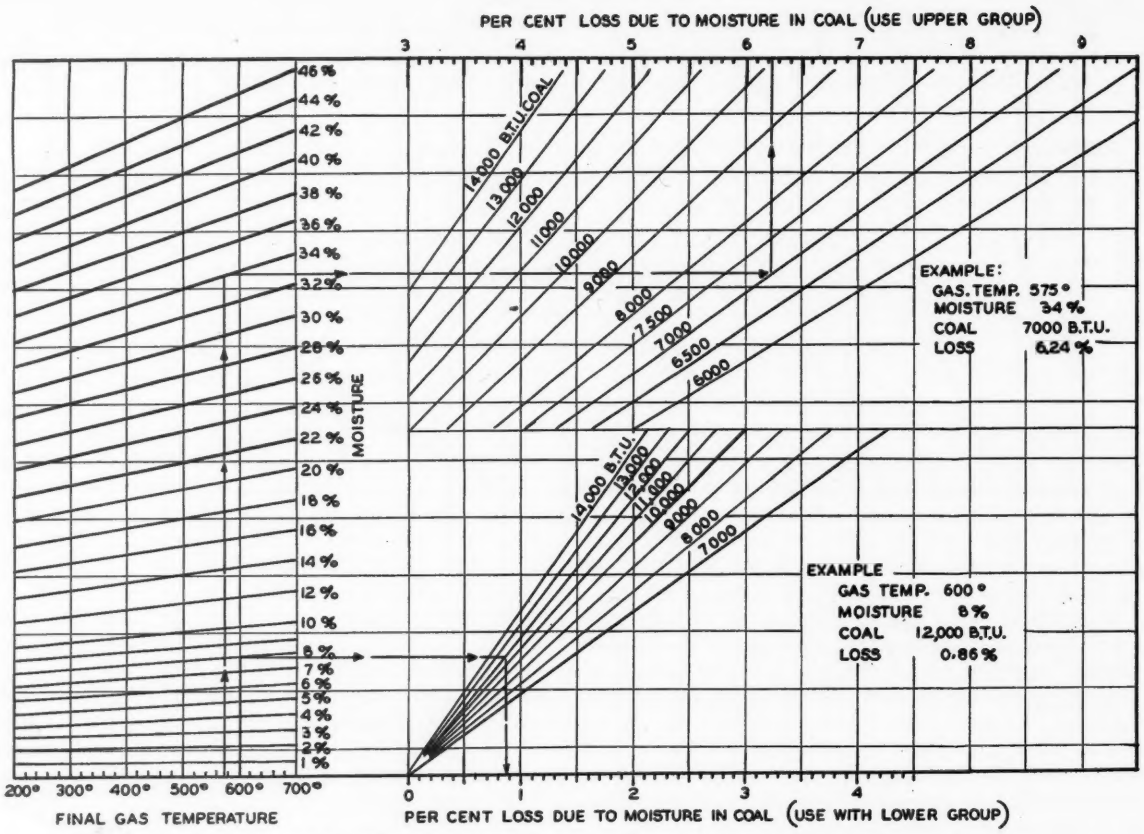


FIG. 4. LOSSES DUE TO MOISTURE IN THE COAL DEPEND ON THE EXIT GAS TEMPERATURE

and those read directly from Fig. 5 exceeds 2 per cent in the case of the No. 2 coal at 700 final gas temperature. Hence, with coals differing widely in moisture and ash content from the graphic analysis shown in Fig. 1, it is advisable to resort to the use of Figs. 2, 3, and 4 in arriving at the determinable losses. By using these charts we obtain the following:

	COAL No. 1		COAL No. 2	
Final Gas Temperature, deg. F.	300	700	300	700
Dry gas loss by Fig. 3, %	5.78	15.85	5.78	15.85
H_2 loss by Fig. 2, %	4.10	4.67	4.10	4.67
H_2O loss by Fig. 4, %	2.73	3.18	.71	.83
Assumed unaccountable losses	4.00	4.00	4.00	4.00
Total losses, %	16.61	27.70	14.59	25.35
Combined boiler and furnace eff., %	83.39	72.30	85.41	74.65
Combined boiler and furnace efficiency by computation	83.44	72.25	85.19	74.66
Difference in use of two methods	.05	.05	.22	.01
Difference expressed in Per Cent	.07	.07	.27	.01

In this comparison, as evidenced from the above, the percentage of error resulting from the use of Figs. 2, 3, and 4 is negligible, and certainly within an allowable tolerance.

As an illustration of the accuracy of the results obtainable by the use of Fig. 5 alone, in determining total accountable losses when used for higher grade coals, the following analysis is submitted. The problem is the same as in the previous case, that is, the determination of the total accountable losses at 14 per cent CO_2 with an unaccountable loss assumed as 4 per cent, and an exit gas temperature of 300 deg. and 700 deg. For this example we will assume two West Virginia coals, one of high volatile, and one of low volatile content. Their ultimate analyses follow:

	High Volatile Coal		Low Volatile Coal	
	As Rec'd.	Dry	As Rec'd.	Dry
Carbon, %	78.99	80.96	83.88	86.55
Hydrogen, %	5.37	5.225	4.70	4.50
Oxygen, %	8.66	6.60	5.62	2.97
Nitrogen, %	1.42	1.455	1.25	1.29
Sulphur, %	.65	.67	.65	.67
Ash, %	4.91	5.03	3.90	4.02
Total	100.00	100.00	100.00	100.00
Moisture, %	2.43	.....	3.08	.....
B.t.u. per pound	14132	14473	14653	15119

By computation the following data is obtained:

	High Volatile Coal		Low Volatile Coal	
Dry gas weight per pound dry coal at 14 per cent CO_2	14.73		15.774	
Computed Heat Balance at deg. F.	300	700	300	700
Dry Gas Loss, %	5.62	15.38	5.77	15.77
Hydrogen Loss, %	3.75	4.37	3.10	3.61
Moisture Loss, %	.20	.23	.24	.28
Total Computed Losses, %	9.57	19.98	9.11	19.66
Assumed Unaccountable Loss, %	4.00	4.00	4.00	4.00
Total Losses, %	13.57	23.98	13.11	23.66
Efficiency by Difference, %	86.43	76.02	86.89	76.34

From Fig. 5 we obtain the following maximum theoretical efficiencies with these coals:

	High Volatile Coal		Low Volatile Coal	
	300	700	300	700
Max. ther. efficiency, %	90.60	80.15	90.90	80.40
Deducting assumed unaccountable loss, %	4.00	4.00	4.00	4.00
Net efficiency by difference, %	86.60	76.15	86.90	76.40
Net computed efficiency, %	86.43	76.02	86.89	76.34
Difference in the two methods, %	.17	.13	.01	.06
Difference expressed in Per Cent	.2	.17	.01	.08

There is little need of greater accuracy in heat balance determination than obtainable by Fig. 5 when used for high grade coals, as evidenced by the above problem.

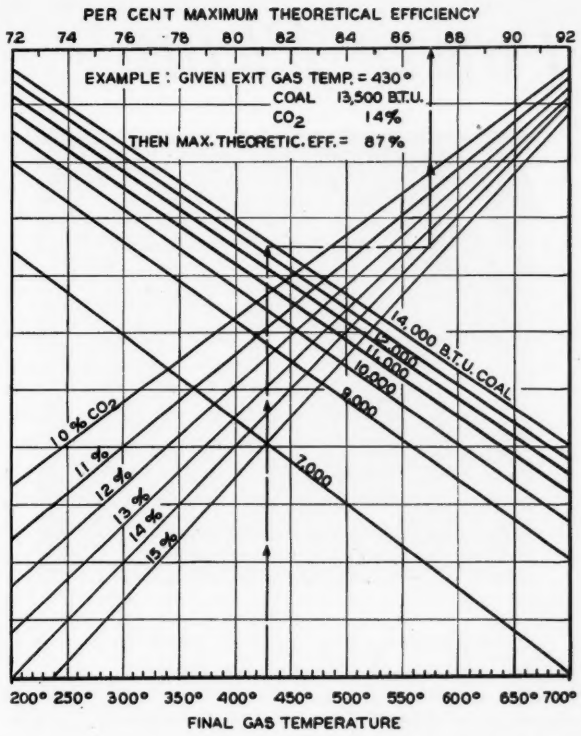


FIG. 5. THE MAXIMUM THEORETICAL EFFICIENCY CAN BE FOUND FROM THE CO_2 READING AND GAS TEMPERATURE. ABOUT 4 PER CENT MUST BE SUBTRACTED FROM THE RESULT FOR UNACCOUNTABLE LOSSES

In pulverized fuel installations, the unconsumed combustible in the ash which settles on the furnace floor should not be greater than a trace. The unconsumed combustible passing through the boiler, however, may be, in some instances, as high as several per cent of the furnace heat input, but in a well designed installation, this loss should not exceed one per cent. The essentials for a low combustible loss in pulverized fuel furnaces are: (1) Sufficiently high furnace temperatures; (2) ample length of flame travel, without short circuiting of any portion of the flame into the boiler passes; (3) complete and uniform mixing of the fuel and air stream, at, or before, entrance to the furnace.

Percentage of unconsumed combustible in pulverized fuel firing will be greater for coals having a low volatile content, and this statement seems to hold true for all grades ranging from lignite to anthracite. As in stoker firing, the percentage of the unconsumed combustible loss, for obvious reasons, will usually increase as the rating increases.

THE TEMPERATURE reached by an electrical resistor is governed largely by the thermal conductivity of the refractory material surrounding it and upon various factors in design. Anything interfering with the dissipation of the heat generated in the resistor raises its temperature. Values of from 8 to 20 watts per sq. in. of conductor area are used in most heating elements. This figure may go as high as 50 watts per sq. in. in immersion heaters. Generally, the lower the temperature the longer will be the life of the resistor.

Short Cut High Temperature Tests

TESTS ON METALS at high temperatures have been going on for a number of years but the results of various investigators have not always checked, discrepancies and discordances being the result of inaccuracies in the methods of test, insufficient realization of the necessity for precise temperature control, too short periods of test and differences in supposedly similar material. Many of these difficulties will be eliminated by the tentative Creep Test Code formulated by the Joint Research Committee on Effect of Temperature on the Properties of Metals, an agency sent up by the A.S.T.M. and the A.S.M.E. to deal with this problem.

Need exists, however, for tests which provide a quicker return than the standard creep tests. Various short cuts have been suggested but so far no definite relation has been found in the short-time and long-time tests. Correlation of these two was one of the original purposes for which the American Joint Committee was formed. They are now considering a correlation program of creep tests to continue for three years under the new tentative code. If sufficient demand from industry exists these same materials will be subjected to various accelerated or short-cut methods that have been proposed. From these methods the rate of creep for three years would be predicted according to the procedure used by the proponents of each method, later compared with the actual results of the three year test. Simultaneous correlation of the two methods would therefore be available from the same material at the same time.

PROGRAM WILL BE CARRIED OUT IF SUFFICIENT INTEREST EXISTS

Such a program will involve considerable expense and cannot be undertaken without assurance of sufficient interest and support to make its completion certain. It is therefore suggested that designers and users, as well as producers of alloys for high temperature equipment, write to the Secretary of the Joint Committee, N. L. Mochel, Westinghouse Electric & Manufacturing Co., Lester Station, Philadelphia, Pa., indicating their interest in such a correlation program. Should the program not be sufficiently welcome to the industry concerned so that a definite desire for its pursual is registered with the committee, the project will not go forward.

INDUSTRIAL USES of Stainless Steel was the title of a talk delivered before a meeting of the American Society of Mechanical Engineers at Cincinnati, Ohio, November 23, by C. C. Snyder of the Central Alloy Division, Republic Steel Corp., Massillon, Ohio. Prefacing his address with a brief history of the development of stainless steel, Mr. Snyder then divided the present large number of different types of stainless steel into the proper main groups, giving their general characteristics and properties. The latter part of the talk stressed the rapidly increasing use of stainless steel in various industries, such as building, meat packing, brewing, automotive and the chemical and allied industries.

POWER PLANT ENGINEERING April 1934

Fundamentals of Power Plant Piping Design

Part I. In this First Article of a Series of Three, the Author Discusses the Preliminary Considerations Necessary to Proceeding with the Actual Design Layouts

By Henry C. Moffett*

FEATURES of piping design in their broader sense, involving as they do the choice of materials and construction methods for the many services, frequently require more time and study than the actual designing of details and the drafting of layouts. Back of final drawings and sets of specifications may be months of study and painstaking tests, spent to discover which of the many materials offered in the market, should be chosen as the most suitable.

Designers must always be ready to discard personal prejudices, and to accept new facts, when exhaustive tests have shown old methods or materials to be obsolete in the light of new discoveries. Every new project presents some new conditions, and these require new decisions.

New methods of doing things are being discovered constantly which are distinct advances in the art, and all designs must keep abreast with the times. By study and practice he must know what is best to do in every case that comes up. Before designs are started, materials that are to be used must be decided upon, and the methods of construction and erection determined and specified.

There are many things which may influence a design. At times the whole arrangement may be chosen strictly from the standpoint of appearance. For instance, when large pipes are necessary that cannot be laid underground and hidden from view, but must be erected in some prominent place, it is necessary to dress up the supporting members, and make sure that the layout is as pleasing to the eye as is possible. In some cases, clearances for headroom, especially in a crowded or compact power house design, will have a great influence on the design, and great ingenuity is called for to solve some of these problems.

It is quite a common thing for a high pressure steam line to be influenced in its design by many considerations which would not have to be taken into account for lines carrying low pressure and low temperature fluids. This is because it is necessary to allow for expansion and contraction, and to provide for the proper drainage of condensate which may form in the line, and to use much heavier materials in the line proper as well as at the joints, and to leave room for a considerable thickness of insulation. It also becomes necessary to consider anchorages, and in some cases spring hanging.

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Important steam heating lines, which radiate from central heating plants, such as those on a college campus, are usually run underground for the sake of appearance, whereas such lines in refineries, where appearance does not matter so much, are erected on poles or towers.

Service of the Line

In power plant piping design work, the piping falls into fairly well defined groups. Each group may be considered as a separate part of the work, for the decisions, choices and treatment of the lines in each group will hold throughout with very few exceptions. It is the service that each line is designed for that places it in a particular group, and the conditions of pressure and temperature, together with the kind of fluid to be conveyed, if approximately similar, determine the group.

Each line should be separately studied, even though it appears to fall into a well known group, and if found not to conform in all respects to the conditions of that group, it should be specified and treated separately.

Occasionally it is not possible to set down all of the final conditions of a given line, for it may be found necessary to make several preliminary layouts and preliminary estimates of cost in order to determine which of the the several possible methods of construction would be the most economical. For example, high pressure steam lines are sometimes required between distant buildings in a factory, or between power houses in the same group of factory buildings. Two general methods are to be compared, the overhead line on towers and the underground line in a tunnel or trench. Appearance in such cases is not a major consideration, hence the decision is based on cost and utility. If streets are to be crossed, the problem is more involved, as there are always certain laws or ordinances to be looked up and observed. If a railroad track must be crossed, permission must be

obtained from the officials of the railroad company, and frequently the company has special designs which must be followed in the layouts of such crossings, based on their experiences or the ideas of their engineers.

Comparisons of cost of overhead and underground pipelines will differ with the natural conditions of the landscape, with the general climate, and with the costs of materials at the time the estimate is made. The kind of soil, especially if rock is encountered may make a very large difference. Proposed lines may require a survey of the courses that are possible, and sets of levels, so that contours of each course may be studied. It is also good practice to have a series of test pits dug along a proposed route, if accurate estimates are to be made for cost comparisons.

The contour of a line, which would be quite uneven if laid underground in a hilly location, could be made approximately straight if erected on towers of varying heights. Even at a higher first cost it is sometimes more economical to keep the line straighter and shorter, as it requires less pipe and therefore cuts down the pressure drop. This is especially true of high pressure steam lines. Water lines and gas lines on the other hand, are practically always laid underground, as the problems of providing for expansion and contraction, and the importance of pressure drop are not so great.

Piping Diagrams and Materials Charts

It is not always possible to start off a design with all of the preliminary questions out of the way, but it is good practice to have these settled as early as possible, and all decisions tabulated and charted for the detailing designers to follow. One of the best ways to keep these important matters constantly before those who must make the final decisions is to prepare comprehensive piping diagrams and materials charts, and keep them up-to-date.

As has been pointed out in previous articles, such piping diagrams help to clarify the ideas that engineers may have in regard to the problems at hand, and serve as proving grounds for those ideas. They also act as an urge to hasten decisions, and eliminate doubts from the minds of the detailers as to the intent of the designs. Diagrams are easily constructed and altered, but should be carefully made. When all data, such as pressures, temperatures, pipe sizes and notes regarding special features are incorporated, they act as a definite guide for those men who must work out the final details.

Diagrams should be made on tracing cloth or tracing paper so that blue-prints may be distributed to all parties interested. From time to time, as the detail design progresses, these diagrams should be made to conform to all changes made in the final drawings and layouts, for the final diagrams are a great help to all field men and operators, as they are often essential to them in gaining a mental picture of the entire piping system and the relation of one line to another, especially if the design is complicated.

A modern power plant requires a wide range of piping systems, from those conveying very hot steam at high pressures to those through which cold water or air flows at atmospheric pressure or in a vacuum. These varied requirements should be symbolized on all diagrams, by lines of different thicknesses, or by dotted or dashed lines. In addition to these differentiations, some engineers employ the use of colored pencils on the prints of the piping diagrams, in order to make the various functions perfectly plain at a glance.

Many attempts have been made to standardize the symbols used on piping diagrams for the various parts and equipment, and some excellent legends have been worked out and used by the trade, but in any case, whether the symbols are generally known and used or not, nothing can take the place of reference notes for clarity, and a legend column for certainty of specification.

General Design of the Lines

It is impractical to try to show everything on piping diagrams unless the systems or pipe lines under consideration are simple. In such cases the specifications for these can be covered concisely in a few words and symbols. Since most lines in a power plant are quite long and in many cases quite complicated, it is often found necessary to put only the simplest data on the diagrams and to make up a separate sheet or set of sheets, on which the material to be used is designated by groups. These materials charts are made up in many forms, but the simplest charts consist of ruled columns with headings for such items as "Kind of Pipe," "Kind of Valves," "Flanges," and "Gaskets," and these are filled out for each system as it becomes known what decisions have been made for each item. These charts may be later incorporated in the general set of specifications.

The first and most important item for each line is the kind of pipe to be used. The higher the pressure and temperature, the more important this question becomes. Some new and important alloy steels are now on the market, and each has its field. It is the designer who must choose the material that will function the best and still not cost so much as to make its use prohibitive. Some alloys are manufactured to withstand high pressures, and these have high tensile strengths as well as great toughness, so that thinner wall pipe may be used. Others are made to resist high temperatures as well as high pressures. Such alloys are quite costly, but permit a great saving to be made in the use of steam in the higher ranges.

Choice of Joints

Next in importance is the kind of joints and the general construction of the line. It must be definitely decided for each system and group, whether the joints are to be of the screwed type, the flanged type or the welded type. Usually such questions are not troublesome, unless we go modern and specify welded joints throughout. Then it must be further decided the kind of welding joint to use, and many other construction features.

As to the general construction of lines, there are many conflicting opinions among engineers and designers. As a consequence, there has recently sprung up a wide variety of offerings by manufacturers, all of which are distinct advances in the art of piping

design. Most of these new features are for use in welded lines, and it is now possible to construct some high pressure lines by welding the joints, which only a few years ago would have been out of the question. This is both because the art of welding has made great strides and the welding materials are much improved, and also because by the use of special welding bends, the problem of the strain at joints has been largely eliminated.

Welded Fittings

General design of welded lines will depend on decisions made as to the use of one or another kind of welding bends. Some are corrugated and some creased. Others are plain smooth bends with long tangents. The use of these specials cuts the cost of a line down and makes possible some installations which would otherwise not be possible on account of interfering fittings and flanges. Smaller radii may be used where the creased or corrugated type of bend is incorporated.

If, in the general design, it has been decided to use flanges for all important joints, the question is only half answered, since there are a number of flanged joints, many of which are standard and some of which are special. The details of the standard flanges are well known, since they are tabulated and published by the standards association, but the details of special flanges may vary. Some special flanges with welding tips are patented. The decision as to the kind of flanges to use, also affects the flanged fittings, as the face to face dimensions of such fittings are not the same for all kinds of flanged joints.

In general, if flanges are chosen which have welding tips, then no gaskets are required, but if the raised face type is decided upon then the proper kind of gasket for that service must be specified in detail. In carefully designed high pressure work, even the thicknesses of such gaskets is taken into account in the fabrication of the component parts of the line as expansion is so important.

Flange Bolt Materials

The materials chart should also show the kind of bolts and nuts that are to be used on all flanged joints. A volume could be written on this subject, as there are a great many kinds of bolts offered, and probably as many kinds of nuts. Engineers as well as manufacturers have run tests on bolts and nuts for years, and metallurgists have vied with each other in producing materials for these items which would have all of the desired characteristics. Many are now considered standard in practice, and many others have special applications.

It is important that the materials chart contain detailed information on all the parts of each line or system. If the line or system falls into a general group, then the group must be specified in detail, so that all lines are covered. Frequently, the specification of a line will change with the change in size, as for instance, when the size is below 1 in. or 1½ in. It is well known that smaller lines may be safe when screwed fittings are used for a given condition, whereas with larger sizes, screwed connections would be unsafe. Large screwed connections are hard to disconnect, and in some cases impossible without destroying fittings. This fact may influence the designer in his choice, especially if the line is one that may have to opened at times for inspection.

Actual preparation of piping diagrams and materials charts, may not always be just the jotting down of decisions as they are made, for it is often the case that engineres must go back to the flow diagrams and heat balance diagrams, and by skillful planning evolve a tentative piping scheme. It is sometimes necessary to evolve several such schemes and then choose the one most suitable as a working basis. From these, a comprehensive plan can be worked out and a piping diagram presented for discussion, and it is this feature that makes the design of piping for power plants so difficult, for the entire answer as to what is best in each case is rarely reached until the last piece of pipe is erected in place, and even then, parts are often scrapped and replaced because some one had a bright idea.

Largest Single-Phase Waterwheel Generator

The largest single-phase waterwheel generator ever built in this country is to be constructed at the Schenectady works of the General Electric Company, for use in connection with the electrification of the Pennsylvania Railroad. Rated at 35,000 kv-a., it is being supplied to the Safe Harbor Water Power Corporation. The unit is to be delivered and erected prior to November 15.

The locomotive motors require 25-cycle single-phase power. Usually the power is generated by three-phase 60-cycle generators and changed to 25-cycle single-phase current by frequency converters. In this case the new generator will be designed to produce the required type of power, thus saving conversion losses which average more than five per cent. It will operate at 100 r.p.m.

Also for installation at Safe Harbor, the General Electric Company is building four 20,000-kv-a. single-phase transformers at its works in Pittsfield, Mass. These are to be delivered by September 1. They will be among the largest ever built at Pittsfield, and are comparable to a number of similar units made more than a year ago, likewise for the Pennsylvania Railroad electrification. The transformers, weighing about 160 tons each, will raise the voltage from 13,000, the generation voltage, to 132,000, for transmission.

The hydroelectric generator and transformers are required by the Safe Harbor Water Power Corporation to prepare for delivery of power to the Pennsylvania Railroad, which has announced that work on completion of the electrification of its lines between Wilmington and Washington is to be resumed as soon as practical.

A high-tension transmission line will connect the Safe Harbor station to the Pennsylvania Railroad's own high-tension lines at Perryville, Md. The generator represents approximately a half million dollars and the transformers more than a quarter of a million dollars.

Vapor Refrigeration System *Characteristics*

Steam Jet or Centrifugal Vacuum Refrigeration Has Wide Field of Industrial Application. Vapors Other Than Water May Be Used

By Paul Bancel*

CURIOUSLY ENOUGH the first refrigeration machine was of the vacuum type. It was invented by Dr. William Cullen in 1755. This consisted of an air pump for exhausting a receiver wherein water, ethyl alcohol, nitrous ether, and other fluids were evaporated under vacuum. Cullen's work was never carried beyond the laboratory stage. In fact it was only after 80 yr. that the American, Jacob Perkins applied Cullen's discovery in a compression system using ethyl ether. Development of water vapor refrigeration has depended on the development of compressing units capable of sweeping very large volumes of low density vapor. These have taken two forms: the steam jet booster and the centrifugal compressor.

Steam jet refrigeration consists of apparatus in which the water vapor boiled off at low pressure is compressed by ejector action of a steam jet and discharged at a pressure high enough to permit condensation by water of ordinary temperature. In addition to the steam jet booster, the apparatus consists essentially of an evaporator and a condenser with auxiliary air pump. The water to be cooled is sprayed into the evaporator. If the water enters at 55 deg. F. and the absolute pressure within the evaporator is maintained at 0.36 in. of mercury, which corresponds to a boiling point of 50 deg., then it is obvious that evaporation must take place until the water is cooled to 50 deg. F. Tables of the properties of steam or water vapor show that the amount of evaporation is approximately one half per cent to obtain 5 deg. cooling. The evaporation loss is replaced by make-up water supplied from an outside source or by the return of condensate from the main condenser.

For each pound of water evaporated, about 3 lb. of steam must be used in the booster jet and accordingly the total discharge of compressed steam and vapors amounts to about 4 lb. The foregoing figure for steam consumption is used for illustration only; the actual quantity of steam will vary widely with existing conditions.

The capacity of a given booster ejector, that is the pounds of water vapor or other gas, drawn in and compressed at fixed suction pressure is approximately constant regardless of the amount of steam being used. This fact is usually hard to grasp. Figure 1 shows a typical characteristic at normal steam flow. The capacity at 50 deg. F. for example is 100 t., if now the steam pressure on the jets is raised 25 lb. and the steam flow in proportion, the capacity at 50 deg. F remains 100 t. It should be emphasized that reference is made to a fixed booster which is operated with steam at different pressures, not to a series of boosters designed for the different pressures and steam flows.

A steam jet refrigerating unit has large reserve capacity. A small increase in chilled water temperature, say, to 55 deg. F. results in a tonnage of 120 per cent, as can be seen from Fig. 1. In general, there is a reserve of between 4 and 5 per cent degree increase in temperature. This is to be contrasted with the decidedly limited overload capacity of the conventional mechanical plant.

A refrigerating plant must not only cope with heavy tonnage demands but also excessive head or back pressures due to extremely hot circulating water. At such times a mechanical unit requires excess power and falls off in tonnage produced or for full tonnage produces higher chilled water temperatures.

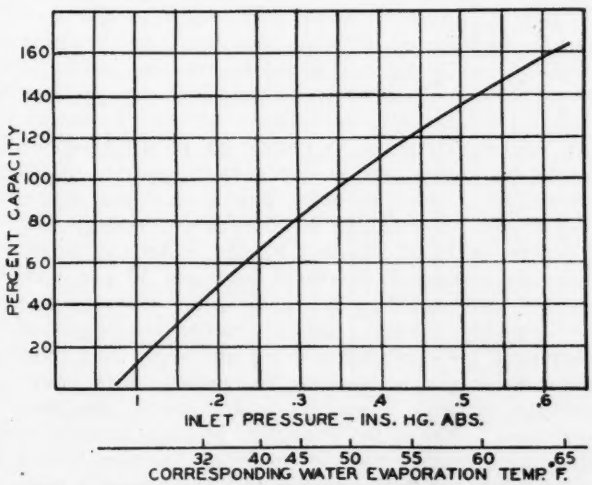


FIG. 1. CAPACITY CHARACTERISTICS OF STEAM JET BOOSTERS

*Ingersoll Rand Co., New York, N. Y. From a paper presented before the A.I.C.E.

A 5 deg. increase in condensing water temperature and an increase of a corresponding amount in head pressure, will increase power consumption, the exact amount depending on the design and refrigerant used; at the same time the reduction in tonnage due to reduced volumetric efficiency and increased heat of liquid will be appreciable and to restore full tonnage the increase in chilled water temperature may be several degrees or more. Under similar conditions of excess back pressure a steam jet unit may fail to function entirely. This characteristic is inherent in the nature of compression by kinetic action.

If the condenser is designed for 85 deg. water and 2 in. back pressure an increase to 90 deg. F. would reduce the vacuum, or increase the back pressure to 2.3 in. With 0.36 in. evaporator pressure the ratio of compression demanded of the booster is thus increased from 5.5 to 6.35, which is beyond a commercial leeway of design. The steam jet booster will therefore break back, that is, it will be unable to compress its own burden or even a small quantity of vapor through the new and higher range of compression. This instability will continue until the evaporation pressure has increased by a relatively large amount and the chilled water temperature is 10 or 20 deg. F. hotter.

Reserve against instability or failure of this type lies in an increase of steam pressure. As shown in Fig. 2 every increment in steam pressure results in a corresponging increase in back pressure against which the booster jet continues efficient operation. An increase from 125 to 150 lb. ga. results in stable operation of the jets against a back pressure of 2.3 as against 2 in. The steam flow is increased about 17 per cent. The chilled water temperature may now be increased about 2½ deg. F., and under this condition the tonnage is increased by about 10 per cent.

The unit therefore has a desirable characteristic of increased tonnage capacity under conditions of extremely hot condensing water and high back pressure which are most likely to coincide with heavy tonnage demands. The heat load, however, has been increased by the added steam flow and also slightly by the added tonnage and the condenser therefore would not produce the back pressure of 2.3 in. unless it were designed to do so. A larger quantity of water so as to maintain the same temperature rise, and additional surface in the condenser as originally installed, would combine to take care of these peak conditions.

Centrifugal Refrigeration

In the centrifugal unit a centrifugal compressor of large capacity takes the place of the steam jet boosters. The heat discharged to the condenser is therefore only the refrigeration load, plus the work of the compressor as with the ordinary refrigerating cycle. An enormous volume of water vapor has to be compressed to a pressure compatible with ordinary condensing water supplies. Since there is no burden of steam load as with steam jets a somewhat better vacuum or lower back pressure can be expected with the centrifugal machine, the possible discharge pressures being 1½ to 2 in. abs. (28 to 28½ in. vacuum). While these pressures may appear low, the ratio, compared to a suction pressure of say 0.36 in., is 4½ to 6 times.

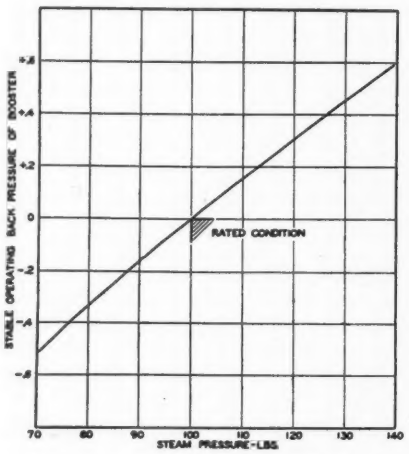


FIG. 2. BACK PRESSURE CHARACTERISTICS OF STEAM JET BOOSTERS

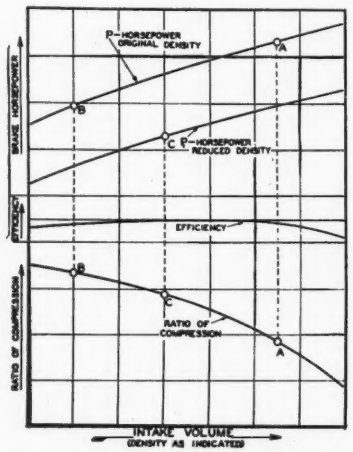


FIG. 3. VOLUME CHARACTERISTICS OF A CENTRIFUGAL VAPOR UNIT

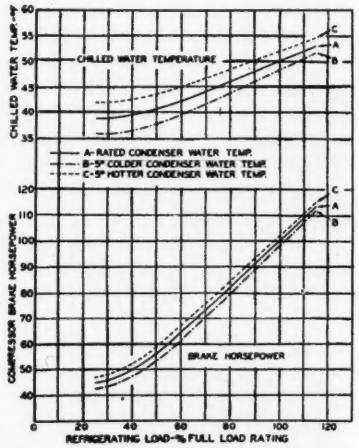


FIG. 4. TONNAGE CHARACTERISTICS OF A CENTRIFUGAL VAPOR UNIT

The compressor is set upon a base which also forms the evaporator and the condenser is attached to the compressor discharge, thus producing a compact simple assembly. Standard sizes ranging from 50 to 300 t. are available. Speeds are from approximately 7000 to 10,000 r.p.m. depending on size.

Brake horsepower requirements of these units involve many factors of design and proportion; of these the efficiency of the compressor itself is probably most important, and there can be no question of the fact that a centrifugal compressor is usually less efficient than a reciprocating machine. This, however, is offset in this instance by the lower theoretical power. As a result the brake horsepower requirements of the centrifugal unit may be said to compare favorably with any type of refrigeration, frequently being less.

Operating Characteristics

The centrifugal water vapor unit differs fundamentally from all other types in its part load characteristics. In general, the centrifugal unit is operated at constant speed. Under this condition and without any other adjustments, reduced tonnage is automatically reflected in reduced power, approxi-

mately in proportion to the tonnage. The unit simply floats on the load.

Figure 3 shows a typical volume characteristic of a centrifugal compressor: as the volume decreases the ratio of compression increases, and over the designed range there is a flat efficiency curve. The power is shown by line P; at part volumes the brake horsepower decreases but not proportionately. A second line P_1 below P shows the power for vapor of lower density. Within limits, a decrease in density at fixed volume results in an equivalent reduction in power. Now, with decreasing load, a change occurs in both volume and density but for simplicity they can be considered as if there were two distinct phases or steps.

First a decrease in volume proportionate to the decrease in load as from A to B. The power then decreases along the curve P from point A to B. Second, a decrease in density and increase in specific volume which now increases the total volume to intermediate value C. Due to the lower density, however, the power is now determined by lower line P_1 and the absolute value at C is less than at B. Three factors; greater compression ratio available; lighter heat load on the condenser and colder condensing water, singly or combined, tend to reduce suction pressure and density.

Characteristics plotted against tonnage are shown in Fig. 4. Condensing water quantity is maintained constant for all three curves of each group; in each group the center line corresponds to rated maximum condensing water temperature, the upper one an extreme maximum 5 deg. F. hotter and the lower one an average 5 deg. F. lower. Horsepower and chilled water temperature are seen to be approximately parallel straight line functions of the tonnage.

As with the steam jet unit only a small increase in chilled water temperature occurs at overloads. Figure 5 shows the comparison of the characteristics of the conventional refrigerating machine with the centrifugal water vapor type. Reserve capacity against excessive temperature of condensing water with the centrifugal vapor unit has already been shown by Fig. 4 in which lines C are for hot water. The effect of a 5 deg. F. increase in condensing water temperature is a corresponding increase in condensing pressure which is reflected in higher absolute pressure in the evaporator. This increase in suction pressure reduces the vapor volume, however, and the ratio of compression attainable increases; this counteracts severe increase in evaporator pressure and temperature. The chart shows the increase in chilled water temperature for 5 deg. F. excessive condensing water temperature and it is particularly noticeable that the spread actually decreases at the heavier loads. The horsepower curves also tend to converge.

Application

Standard steam jet or centrifugal machines are not designed for cooling brine or for producing freezing temperatures. Temperatures from 35 deg. F. up can usually be obtained but in general low temperatures should not be specified except for part load. A chilled water temperature around 50 deg. F. is the normal rating of water vapor units. While the over-

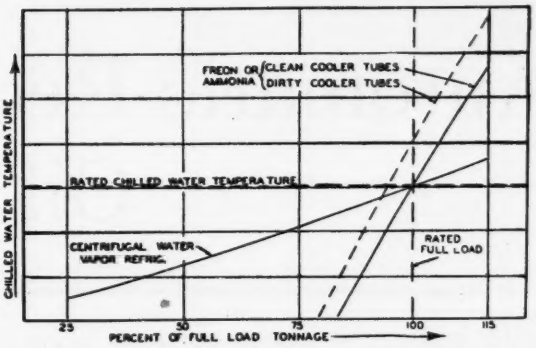


FIG. 5. OVERLOAD CHARACTERISTICS OF A CENTRIFUGAL WATER VAPOR UNIT VS. A FREON OR AMMONIA UNIT

load characteristics are remarkable and highly valuable, the author wishes to emphasize strongly the futility of underestimating operating conditions in the expectation that any machine can make up for the user's carelessness in selection. Tonnage can be rated closely, but should not be underestimated.

Maximum condensing water temperature should be definitely anticipated and specified; this is particularly true with cooling towers and ponds which in the author's experience tend to be rated on more favorable wet bulb temperatures than may actually prevail for appreciable periods of time. This is all the more important if the greatest tonnage is most likely to occur at times of extreme atmospheric conditions, thereby producing cumulative effects.

Highly attenuated vapors other than water vapor can be compressed by either steam jets or centrifugal boosters; it must be remembered, however, that the discharge pressures are still relatively low, 1½ to 2 or 2½ in. and that they are attained by condensation so it is generally necessary to confine applications to condensible vapors. It is the author's belief that other applications besides water vapor refrigeration are possible in many industrial processes where it is desirable to raise the pressure and heat level. One such application is in low temperature evaporation where vapor can be recompressed and returned to the system.

An analysis of non-Federal allotments as of January 10 showed that waterworks, sewers and schools topped the list in number, although projects classified as bridges and structures headed the list in size of allotments. A summary of this survey follows:

Character	Number	Allotment	Percentage
Waterworks	451	$ 66,666,972	10.6
Sewers	347	133,964,260	21.3
Schools	330	62,548,539	10.0
Streets & highways	273	40,468,935	6.4
Bridges & structures	83	163,530,245	26.0
Hospitals	78	27,415,794	4.4
Other buildings	171	26,297,870	4.2
Power	44	27,258,900	4.3
Housing	20	48,771,958	7.8
Recreation	12	2,371,620	0.4
Miscellaneous improvements	67	28,664,505	4.6
Totals	1,876	$627,959,598	100.0

POWER PLANT ENGINEERING April 1934

Automatic Reclosing *of* Oil Circuit Breakers

By A. E. Anderson
General Electric Company

THE RECLOSING OIL Circuit Breaker is a device which can greatly improve the quality of service on any system subject to occasional fault. Where ordinary, non-re-closing circuit breakers are used, the occurrence of a fault usually means a temporary interruption of service, since the circuit breakers trip out and must be re-closed by the operator who may or may not be in the immediate vicinity. With the re-closing type of breaker, this is accomplished automatically and if the fault persists, the breaker will try to restore service several times before it finally locks out or clears the fault and remains closed. In this article which is an abstract of a paper presented at the winter meeting of the American Institute of Electrical Engineers in New York, Jan. 23-26, the author discusses this type of equipment and its application.

WHEN A FAULT occurs on an electrical circuit, the first requirement to be met is that of isolating that portion of the circuit from the rest of the circuit breaker. This function is performed automatically by the automatic oil or air circuit breaker.

Once the faulty section of the line is removed, the dielectric in the path of the fault, except in case of a solid ground or short, recovers its insulating properties and, as a rule, the isolated portion of the circuit may be reconnected to the source of power.

Before the development of reclosing breakers, this "reconnection" was accomplished by the operator, who, unless the breaker opened immediately closed it again by hand.

In case, however, that the fault path had not recovered its insulating properties, the circuit breaker was provided with a trip free mechanism, which immediately opened the breaker again, despite the fact that the operating lever was still in the operator's hand and in the closed position.

In the modern reclosing circuit breaker, these operations are all performed automatically and initiated by the fault current. When the fault occurs the breaker opens instantly. Then, after a suitable predetermined interval, the breaker closes automatically and if the fault still persists, it will open again at once. This may be repeated another time after which, if the fault continues to exist, the breaker is finally "locked out" in the open position.

As a rule, however, most faults clear themselves after the first opening of the breaker, and the breaker remains closed after the first reclosure. During 1931, the Alabama Power Co., Georgia Power Co., Tennessee Electric Power Co. and the West Penn Power Co. made a systematic study of the percentage of such successful reclosures. During this period approximately 2900 initiating operations were observed with the following percentages of successful reclosure and lockouts.

Reclosure	Breaker Remained Closed
First	86.9%
Second	3.4%
Third	0.9%
Lockout	8.8%

Automatic reclosing breakers have been in general use for about 12 yr. A majority of the applications fall in the 2300-4600 v. class, with a maximum of 154 kv.

A greater part of the earlier installations were made on feeders on which lighting load predominated. A commonly accepted reclosing cycle was 15—30—75 sec., this cycle continuing in use up to the present time. The 15 sec. interval was an arbitrary choice and represented a marked improvement over previous manual reclosing, sufficing as a minimum value for several years. The remaining intervals were also arbitrarily chosen with some consideration towards lessening the duty on the oil circuit breaker in case of successive operations.

Occasionally the questions is raised concerning the possibility of automatically measuring the impedance of an a.c. feeder in order to determine whether or not the breaker should reclose. Such equipment for a.c. circuits has been built and tested but the results were not successful from an economic point of view due to a number of reasons. For example, a large part of the load on the conventional a.c. circuit consists of lamps whose cold resistance may be only 10 per cent of the hot resistance. If a small load indicating or load measuring current is used it is difficult to distinguish the difference between a short circuit and a useful load. Soon after a.c. reclosing equipment began to be applied more generally, it was found that from 75 to 90 per cent of the openings of breakers were caused by transient faults that disappeared after the first, second or third opening.

Factors Involved in Selecting Reclosing Equipment

The improvement in service resulting from the use of immediate initial reclosure cannot be obtained without first taking into consideration some conditions

which are of secondary importance when time delay initial reclosure is employed. The first of these factors, of course, is the cause of the outages. On overhead a.c. systems these for the most part are of a transitory nature and as a rule can be cleared by removing the voltage long enough to extinguish the arc.

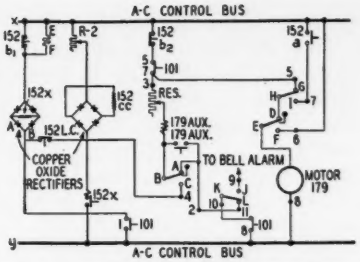
The next factor is the induction and synchronous motor load on the system. During the period that the fault exists and the circuit breaker is in the open position, any motor connected to the feeder will in all probability be operating at reduced or zero voltage. This will retard the speed and may be ruinous to certain products in manufacturing industries. Even though the product is not affected, there may be cases where the motor cannot return to normal speed when the feeder voltage is restored. In many instances, however, the products are not affected and intervals of 2 to 4 seconds have been encountered without ill effects. Generally speaking, induction motors will return to normal speed from any reduced value, inasmuch as their load usually is connected directly from standstill to normal operating speed. However, the longer the de-energized period the greater the decrease in speed resulting in higher inrush current.

Synchronous motors will not necessarily pull their load back to normal speed after a voltage interruption. Their ability to return to normal speed under this condition depends largely on pull-in torque and load characteristics. Those motors (50 to 60 per cent) that can resynchronize under load from any decrease in system voltage or from sub-normal speed, will, in all probability require automatic field removal and resynchronizing equipment. Such equipment is readily available. Those motors (40-50 per cent) that cannot resynchronize under load from any decrease in system voltage or from sub-normal speed, will, in all probability, require automatic field removal and resynchronizing equipment. Such equipment is readily available. Those motors (40-50 per cent) that cannot resynchronize due to torque or load characteristics will require in addition suitable unloading features.

Although in some instances synchronous motors have remained connected after an interruption without the use of the above equipment, such occurrences usually can be accounted for by certain load conditions or the presence of sufficient reactance in the system to absorb the out of phase current. Synchronous motors (due to a small amount of stored energy) pull out of step rapidly when carrying full load. Under this condition they can stand complete loss of voltage for only 2.5 to 5 cycles and still remain in synchronism. The restoration of normal operating voltage within this extremely short period is not available with present equipment. Furthermore a period of 2.5 to 5 cycles without voltage may not be long enough to allow the dielectric in the path of the fault to recover its insulating properties to a degree that will permit successful re-establishment of normal operating voltage.

Synchronous motors (and condensers) tend to maintain arcs caused by the fault. Obviously the duration of these arcs will affect the choice of suitable reclosing equipment.

Lighting loads impose no particular problem in connection with immediate reclosing.



Circuit for immediate initial reclosure. Devices shown in position following opening of oil circuit breaker but prior to immediate reclosure.

When breaker trips 152 b-2 closes, energizing 179 auxiliary ("anti-pump" or "set-up" relay), releasing BA and ED and closing BC and EF; 179 auxiliary closes and seals itself in. BC in closing completes circuit to 152-X and its rectifier, through latch-checking switch. Then 152-X picks up, energizing 152, closing coil through its rectifier. EF in closing seals motor circuit to X.

Undervoltage devices on motor controllers, however, require consideration. If service conditions are to be improved by quick re-establishment of voltage these devices must not disconnect the motor controller during the reclosing period. Instantaneous undervoltage equipment as a class will not fulfill this requirement since they will drop out within a few cycles after voltage has decreased below their drop out value. Time delay undervoltage devices are required in order to take full advantage of the initial reclosing cycle. The available timing interval of the undervoltage device for use with immediate reclosure should be long enough to overlap (1) the duration of the fault; (2) the time the breaker is open and (3) the time it may require the system voltage to return to at least the pick-up value of the device.

Requirements Due to Presence of Air Circuit Breakers for Low Voltage

Although oil circuit breakers are used in a large portion of a.c. reclosing equipments available, nevertheless air circuit breakers have also been used in this manner, principally on low voltage circuits. The general features mentioned in this article in connection with oil circuit breakers apply equally well to air circuit breakers. Oil circuit breakers and mechanisms are available having minimum operating times in the order of from 30 to 80 cycles on a 60 cycle basis, depending upon type and rating of the breaker and form of mechanism. Many oil circuit breaker mechanisms utilize a latch that must be reset before the closing force is applied to the breaker. It is necessary to make sure that this latch has reset before the closing effort is applied. Most available mechanisms of this type require a latch checking function. A time delay device can be used for this purpose but such a device must have a setting long enough to take care of the various limiting conditions such as those due to seasonal variations and variations in operating voltage thereby preventing the minimum time from being obtained under the most advantageous conditions.

In the application of immediate initial reclosure consideration must be given to the protective relay system. First, circuit closing protector relays must open their tripping contacts with some safety factor during the de-energized period. Most over current relays of recent manufacture readily meet this requirement. Some of the older types which require a comparatively long time to reset can be modified readily to give the desired quick resetting feature.

The electrically operated devices available for producing the required reclosing impulses while differing in detail consist of the following elements: Release mechanism; timing mechanism; contacting mechanism; anti-pump means and lock-out means. When conditions on the feeder circuit are normal and no operation of the device is required, the reclosure is held in its so-called normal position either by a mechanical stop or by an open contact in its operating circuit. The closing of a "B" auxiliary switch on the circuit breaker energizes the release mechanism thereby placing the reclosure in operation. The timing mechanism ordinarily consists of a motor driving a contacting mechanism through a suitable gear train. The contacting mechanism usually consists of two sequentially operated contacts, the first closing the circuit to the set up or anti-pump relay which seals itself in through the "B" switch. The second contact completes the closing circuit of the breaker through the set-up relay contacts. The closing of the oil circuit breaker following the operation described for the timing mechanism releases the set-up relay. In this way pumping of the breaker is prevented as the sequential operation of the contacts must be repeated before another closing impulse can be given. The lockout means stops the reclosing after the third successive operation if the breaker fails to remain closed.

Most of the reclosers furnished until recently could be adjusted for a minimum delay of 1 to 3 sec. for the initial duration. Usually this is not fast enough where immediate reclosure is desired and often reclosers of early design can be modified so as to be suitable for immediate reclosing duty. In stations where operators are available a great improvement in service is possible by applying a reclosure for one operation and leaving resetting and subsequent reclosing to the operator. Where desired a reclosing device actuated directly by the breaker mechanism is available in the form of a hermetically sealed tube containing mercury. This device gives 1, 2 or 3 reclosures at fixed intervals of time. This is accomplished by means of orifices through which the mercury flows into various chambers within the tube. This flow provides the desired intervals between reclosures as well as the time required for resetting. These intervals are independent of each other. When the breaker opens the tube is rotated to a vertical position where contact is made after sufficient mercury flows into the contact chamber from the initial chamber, thus reclosing the breaker. When the breaker recloses the tube is returned to its original position and the mercury in the contact chamber is admitted quickly into the lockout chamber. After a predetermined number of successive operations within a prescribed time, the mercury is all accumulated in the lockout chamber, leaving none with which to make contact and the breaker is locked out. If the breaker remains in the closed position for a sufficient length of time the mercury is returned to the resetting orifice to the initial chamber. The "timing" orifice can be enlarged so as to give no reclosing operation within 30 to 60 cycles. A number of these tubes can be grouped together so as to give different time intervals between reclosures.

Diesel Diagnosis
with Pyrometer and Indicator

These invaluable aids to operation should be the constant companions of the engineer

By William Sheffer

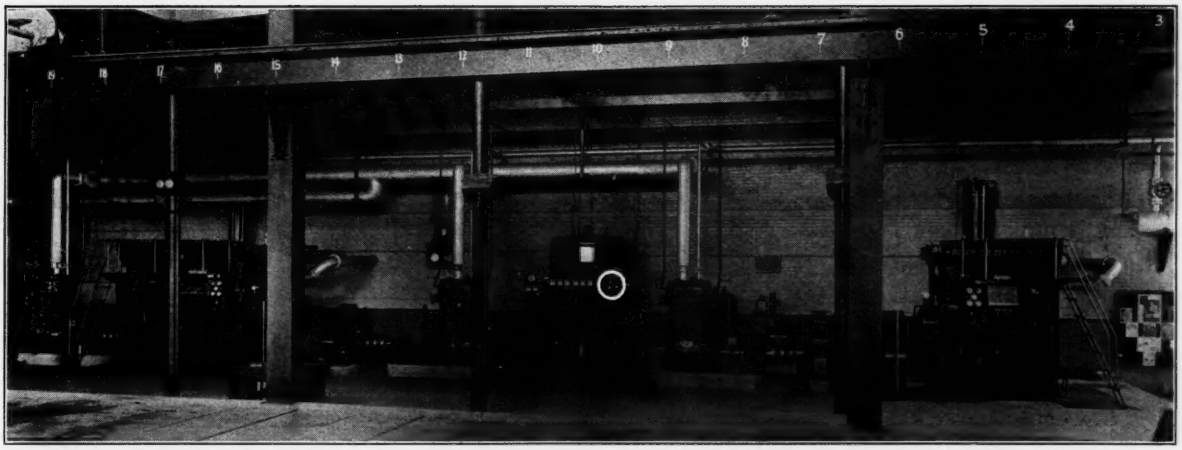
UNFORTUNATELY the majority of Diesel operators fail to realize the benefits to be derived from the proper and intelligent use of an engine indicator and pyrometer. Every operator of this type of prime mover should possess these instruments and thoroughly acquaint himself with the use of them. It has been the experience of the writer that all too few Diesel plants are equipped with these necessary adjuncts to efficient operation.

Many engineers place too much dependence on the sound and color of the exhaust. While a weak or miss firing cylinder can be detected by the sound of the exhaust, and an improper or poorly timed fuel system sometimes noted by the color of the gas, too much dependence should not be placed on this method as the offending cylinder is not readily placed and the detection of trouble calls for a lot of cut and try trouble shooting.

Every Diesel engine should be equipped with a pyrometer connection on each cylinder exhaust manifold as the temperature of the gases tell a long, and sometimes sad, story to the engineer. An auxiliary method of obtaining correct and economical operation is desirable and an indicator is in order.

There are several makes of indicators on the market, obtainable with various scale springs and piston sizes, to take care of installations operating at any pressure or speed. A reducing motion, while convenient, is not necessary, as with a little practice out of phase cards can be taken successfully. The operator will soon prefer this rapid method of taking cards as an out of phase card is as easily interpreted as the conventional diagram.

Compression cards of each cylinder should be taken. Then a low side card should be obtained. This is a diagram of the suction and exhaust stroke, taken with the cylinder not firing. To do this, it is necessary, because of the wide range of pressure in a



A CONVENIENT AND ECONOMICAL INSTRUMENT BOARD WITH THE PYROMETER INDICATOR MARKED BY A WHITE CIRCLE Photo Courtesy of Illinois Testing Laboratories, Inc.

Diesel, to install a light spring in the indicator, so that the diagram will be high enough for a useful reading. After this, out of phase, full cycle cards should be obtained.

All the information possible concerning valve timing, fuel injection, compression and injection air pressure, should be obtained from the manufacturers of the engine being worked on so that one will have the proper foundation to work on.

A careful study of the diagrams should then be made, the results compared with the manufacturer's instructions and the necessary corrections and adjustments made. The value of the indicator is soon apparent in the form of a quiet running engine, fully up to the traditional Diesel efficiency. It must be remembered that faulty valve timing and fuel injection will remove from even a mechanically snug and shipshape engine all the reliability and economy built into it by its makers.

Exhaust gas temperatures of Diesels vary much, according to the manufacturer, type, and class of service of the individual engine, that the remarks concerning the use of pyrometers in the exhaust manifolds must of necessity be general. A thermocouple should be inserted permanently in the exhaust manifold of each cylinder, and the leads run to an electric pyrometer whose number of contacts coincides with the number of cylinders of the individual engine. The instrument itself will be found to be practically trouble proof, and the engineer will only have to keep the thermostat unit reasonably free from carbon and scale. These scale formations act as a heat insulator, and as the thickness of the deposit will vary from time to time and from cylinder to cylinder, the different and changing insulation values may cause an appreciable error in the pyrometer readings.

Each cylinder temperature will vary slightly from the other, and a change of load will of course cause a change in the temperature of the exhaust gas. With the majority of engines the temperature will run almost in a straight line from about 250 to 750 deg. F., from no load to full load. In a two cycle engine using scavenging air, the temperature will be considerably cooler due to the action of the scavenging air as it sweeps the burnt gases from the cylinder. Learn the characteristics of your particular engine before applying the corrections indicated by the pyrometer readings. A temperature variation of 10 to 25 deg. F. for the different cylinders is permissible.

A low temperature indicates that the cylinder is not doing its work, either from a faulty fuel pump, leaky valves or rings, or, in mechanical injection engines, improper lift of fuel valve. Very high temperatures indicate that the cylinder is getting too much fuel and combustion is incomplete (similar to retarded spark in a gasoline engine); that the cylinder is overloaded; that possibly the cooling water supply is not sufficient, or that the passages in the head and cylinder are clogged. Cooling water outlet temperatures will run from 100 to 140 deg. F., depending on the engine and the inlet temperature. The supply of scavenging air might not be adequate. A temperature that varies greatly in one cylinder indicates a lost or weak motion in the governor mechanism. Check for clevis, bushing, cam and fuel wedge wear and lost motion.

It will be seen from the above that a pyrometer is a necessary accessory to a Diesel engine, and when used intelligently in conjunction with an indicator, the engineer will be able to diagnose ills that an engine may be subject to.

BASIC EFFICIENCY of a reaction turbine stage of great blade heights can probably be brought as high as above 95 per cent. The discrepancy between this value and the present values of turbine efficiency of from 70 to 85 per cent is often a surprise to the purchaser of steam turbines.

Principal sources of loss which cause the discrepancy between the ideal and the actual efficiencies are: (a) Losses due to the impracticability of having every stage operate at its maximum efficiency; (b) leakage of steam in the stage; (c) leakage of steam in glands and balancing pistons; (d) end effects (and leakage disturbances) preventing ideal flow; (e) disturbances due to mechanical details such as lashing wires, reinforcements of blades, etc.; (f) leaving and exhaust loss; (g) losses due to the presence of moisture in the low pressure region; (h) mechanical losses due to friction in the steam path and in bearings.—C. R. Soderberg, W. E. & M. Co., before the N.A.P.E.

Readers' Conference

Pulsations in Gravity Bucket Conveyor Chains

In a gravity bucket conveyor system it is noticeable that the chain pull varies in speed owing to the fact that all long pitch chains have a slight pulsation in an ordinary plain loop system. The whole drive has a factor of safety to cover this extra strain, but in a more complicated system as the pulsations are generated at the idler sprockets the extra strain would be serious if these pulsations added up instead of equalizing out. Equalizer gears may be used but these do not render unnecessary the careful spacing of the idlers. This can be done by splitting the system into sections and so arranging that alternate sections contain a whole number of pitches.

The center to center distance of corner shafts should be made equal to a whole number of chain pitches. Any pulsation introduced at one idler cancels the pulsation already in the conveyor. It is only when pulsations add up that trouble results.

In one installation having six corners due to bad spacing the chain only lasted 3 yr. It was proved that a pulsation was introduced at each corner of the chain path, each pair of idler sprockets generated pulsations which added up, whereas they should have cancelled out. This serious wear on the conveyor was remedied by more regular spacing, which cured the trouble.

Herts, England. W. E. Warner.

Welded Boilers

As a chief engineer who has had considerable welding done by experienced welders upon return tubular steam pressure boilers carrying 150 lb. to the square inch, I was deeply interested in the article by C. C. Custer on page 150 of Power Plant Engineering for March 1934. The letter no doubt contains much valuable information, but the information is not of great value to many engineers in charge of steam power plants who seldom, if ever, do much welding personally.

I have had fire cracks welded, also patches put on, and where the welding was properly done and the proper material used in the joint, there were no leaks; the work held up against all stresses for a great many years. What the engineer in charge has to make sure of is that the surrounding plate has not crystallized or is defective in other ways. Cleanliness is a necessity when doing such welding, especially so when using old plate or other material. My own personal opinion, based on experience, is that no plate or weld will give way from low water or heat before the other parts of the boiler if the plate and the weld are right, which is contrary in some respects to what Mr. Custer says on page 151.

If the rear head ends of steam boiler tubes persist in leaking, the method successfully used many times is to clean out the tube holes in the boiler plate and use narrow, thin strips of sheet copper upon the tube ends before rolling them in the steam boiler head. I do not remember of ever seeing a leaking tube end when this method was used, other things being right. Personally I believe welding is good practice when the welding is done by competent welders who understand what they are doing, but such welding cannot be done by the average man.

Toronto, Can. James E. Noble.

Pointers on Belt Selection

Considerable trouble is often experienced with belting, due to the fact that its thickness and width is not carefully selected to meet operating conditions. But as there are so many problems that enter into a belt drive, if it is to give efficient service, it is impossible to give a fast and set rule that will apply to all drives.

As the belt transmits its load from the gripping power on the pulley, it is therefore evident that anything done to increase the arc of contact between pulley and belt is an advantage.

When to choose between a single or double-ply leather belt, or the number of plys on a rubber belt, depends on the belt speed, horsepower to be transmitted, center distance between pulleys, the diameter of the pulleys, and their ratio.

The reason for going to a multiple-ply belt is to transmit the required load within a reasonable width of belt and pulley face.

Maximum recommended width of single-ply leather belts is 8 in. Using this value as a limit, it means that it is necessary to go to a multiple-ply belt when the load is too great for the 8-in. single-ply.

A case where a double-ply belt might have to be used, within the range of a single-ply belt, is on a machine where a pulley face wide enough to run the single-ply belt on is impractical. Example: When a drive is calculated an 8-in. single-ply belt may be satisfactory, but an 8½ or 9-in. pulley face can not be used in the available space. This would mean falling back to a 4 or 6-in. double-ply belt to carry the load.

For efficient power transmission a belt must be pliable. For this reason a single-ply belt is preferable on pulleys of small diameter. While, again, pulleys of suitable diameter and traveling at slow speed and on long centers might call for a double-ply belt in case the slack side is on the top, the added weight being needed to sag the belt in the center, thereby increasing the arc of contact on the pulleys, which means increasing the efficiency of the drive.

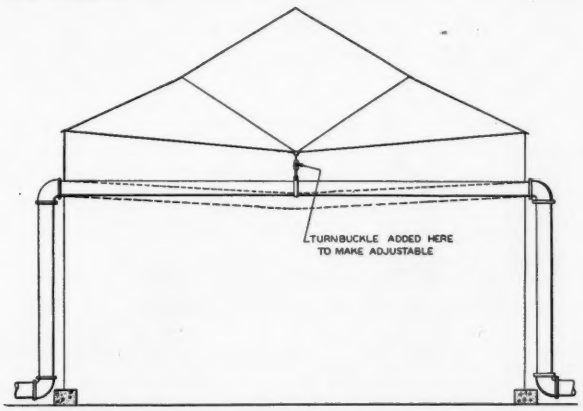
Where pulley ratios are abnormal and on short centers requiring an idler pulley, the single-ply belt is preferable if the load to be transmitted falls within

the 8-in. limit in width. The single-ply belt will wrap the small pulley better and withstand the double bending action over the pulley and under the idler, than the double-ply belt. This means increased belt life and less belt maintenance, due to less separation of splices and plys. Where a belt properly grips the pulley its load is transmitted under less belt tension, thereby subjecting the bearings and machinery to less wear. All of which goes towards decreased maintenance and repairs, a good point in favor of the proper belt.

Niagara Falls, N. Y. MARIN PHILLIPS.

Water Hammer in Steam Pipes

WATER HAMMER can be dangerous and it is always annoying especially in heating systems where the noise can be heard and sometimes felt throughout the building. Even though it is not as dangerous as in high pressure steam lines it gradually causes leaks in the joints and usually in the most inaccessible place. An odd case of this kind occurred in a system that had not caused trouble before. It finally got so bad in the mornings that something had to be done. Everything seemed to be all right, the line was drained and the traps working. By noting the rapidity with which the traps discharged we gradually traced the water back to a section where the line crossed an old building. Careful inspection of this section soon revealed the trouble.



AN ADJUSTABLE HANGER MAKES IT EASY TO ELIMINATE WATER POCKETS LIKE THIS

This old building had gradually settled until there was a regular U in the line and this formed a pocket which filled up during the night. When steam was turned on the radiators in the morning all this water was forced over the top of the U so fast that the traps couldn't handle it and it continued along and bumped at every corner and turn. Apparently the settling had been going on for many years but it was not until it got so low that the pipe was practically full that real trouble developed.

The cold spell with the extra load gave sufficient steam velocity to pull the water over faster than the traps could handle it. A turnbuckle inserted in the hanger soon corrected the difficulty and eliminated the knock. Elimination of this danger in steam lines is easily provided for by the use of adjustable hangers.

Springfield, O. F. PAUL.

Doubling in Brass

FOR MANY YEARS it has been customary with traveling theatrical companies to require many of the actors not only to play their regular roles during the show but also to play some musical instrument in the street parade that usually preceded the show. This is known as "doubling in brass."

Industry can also find double duty for many of the machines they use. An instance of this kind has just come to light in one of the prominent industrial plants. In this particular plant a considerable number of industrial, battery-operated trucks were used to transport material from point to point in the plant. The facilities for charging these batteries were somewhat inadequate so a portable electrical welding machine was tried out as an auxiliary battery charging unit. This was found to operate very successfully so the maintenance crew now uses the welder during the day for routine repair work while at night the welding machine does double duty as a battery charger.

South Bend, Ind. CHAS. A. PETERSON.

Variable Pressure Boiler Operation

AFTER READING the discussion on this subject by N. T. Pef in the November issue and Harry M. Spring in the February issue, it can plainly be seen that both are right but they both neglect one point which is of vital importance, the heat content of the saturated steam.

With the 400 lb. installation as described by Mr. Spring a considerable portion of the lowered heat content of the steam at the turbine throttle was due to the lower temperature and lower heat content of the saturated steam at 300 lb. for it must be remembered that the combustion rate would have to be decreased and the furnace temperature lowered with the decreased turbine load regardless of the pressure at which the boiler is operated, therefore the heat input of the superheater would be practically the same in either case.

Operating under such conditions where lowering the steam pressure results in a materially decreased heat content would in most cases prove to be decidedly uneconomical, the increased turbine water rate and resulting condenser losses more than offsetting the slight gain in boiler efficiency.

While this is true of any operating pressure below that at which saturated steam contains the maximum heat, it is, however, no criterion that operating with variable pressure on higher pressure boilers is not practicable.

Mr. Pef has in mind a 600 lb. plant. In this case the pressure could be lowered to 450 lb. without lowering the heat content of the saturated steam and consequently without materially lowering the total heat at the throttle, under that of full pressure operation. On still higher pressure boilers a slight gain in total heat at the throttle may result from lowering the boiler pressure, it is in the higher pressure field that variable pressure operation may be expected to meet with greater success.

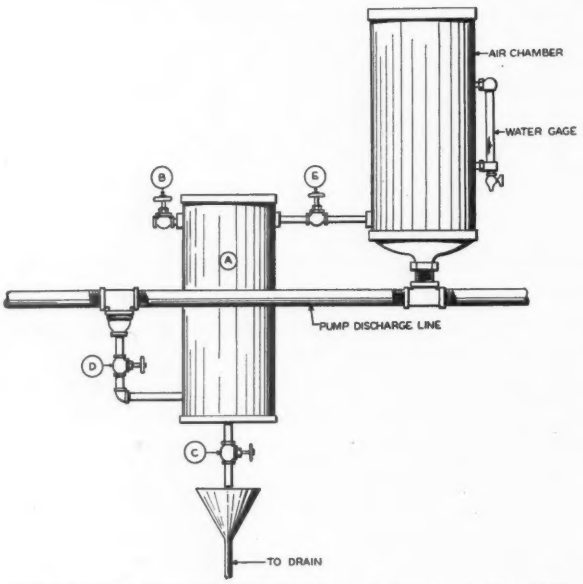
South Amboy, N. J. RAYMOND SEPTOR.

Air for Air Chamber

AIR CHAMBERS for pumps or other purposes may be charged in the following simple manner. "A" represents an air receiver made up of a piece of pipe and fittings, of suitable size to provide a vessel of the capacity required for one charge of air.

When the air chamber requires more air as indicated by the level of the water in the gage, valves B and C are opened while valves D and E are closed, thus drawing all water out of the receiver A, which is then full of air.

The next operation is to close valves B and C, and open valves D and E. Water then flows into the receiver A under operating pressure and the air is forced into the air chamber until the gage indicates that there is enough air in the chamber. Valves D and E are then closed.



CONNECTIONS FOR INTRODUCING AIR INTO AIR CHAMBER

It will be seen that with obvious modifications, a similar hook-up may be used for introducing solutions into feed or other lines.

There is, of course, nothing particularly novel about this method, but it makes such a practical and economical arrangement that many people may find it useful. One of the chief advantages is that air at exactly the right pressure is available at all times for charging the air chamber.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Carelessness Causes Oil Fire Explosion

IN A LARGE industrial plant, operating three shifts, the midnight shift in the boiler room consisted of a fireman and a handyman. The handyman's first duty was to clean the oil strainer, a twin type, having a sliding gate on each side to cut in one of the strainers and the other out.

On the morning of the explosion, the handyman started as usual to clean the strainer by adjusting sliding gates and opening bleeder valve. The fireman noticed a drop in the oil pressure and opened the burner valve further and went to the central pumping station to see if the attendants were having trouble, but he found they were not, and on returning to boiler found the fire still lower and opened the valve still further. When he got no increase in his fire he suspected local trouble.

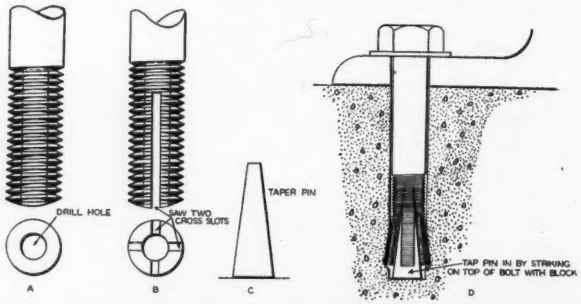
The handyman noticing the fireman's predicament checked his sliding gates and found one in and the other out, thereby cutting off the entire supply of the boiler room. Without notifying the fireman he opened the sliding gates correctly, allowing a flood of oil to enter the firebox. This flood of oil that came through an open valve and the oil that dribbled into firebox ignited with a violent explosion, wrecking baffles and cracking brick work on side walls. The fireman was slightly burned, as he was about to close his oil valve when the explosion occurred.

Brooklyn, N. Y. WILLIAM ANDERSON.

Quick Improvised Expansion Foundation Bolt

HERE IS a kink that shows the correct way to improvise quickly foundation expansion bolts for use in drilled holes in concrete. The sketches almost tell the complete story but a few words make them more clearly understood.

The bolt to be used is put in the vise of the drill chuck or in the lathe and a hole drilled part way into one end as a A, next this end is cut into four sections by two crosswise hack saw cuts as at B, then a taper pin is filed to the type shown at C. This pin is lightly tapped in the end of the bolt and then the bolt is inserted into the hole and when it reaches the bottom the nut is put on and the bolt driven down onto the taper pin. This will expand the four cut sections into the hole and secure the bolt, as is shown at D.



EXPANSION BOLT FACILITATES REPAIRS

Concord, N. H. CHAS. H. WILLEY.

Excess Slip in Induction Motors

SLIP IN INDUCTION motors is often excessive owing to the voltage drop between the brushes being greater than the designer calculated. The clutch on motors provided to short circuit the rings when the motor is up to speed should be maintained in first class condition so that it works without lag. The brushes should be well bedded so as to give good contact and

a minimum voltage drop, any connections between the brushes and the rheostat must be well made so that there is a minimum loss. The resistance of the brushes chosen should be the same as called for by the design of the motor. Good contact must be had between the bars and the end rings, the applied voltage must be kept at that for which the motor was designed as a low voltage affects both the efficiency and the slip. In wound motors whether the brush gear is only used for starting or speed regulation, the voltage loss in the whole brush gear circuit must be kept to the minimum possible or the efficiency will be reduced and the slip increased.

Herts, England. W. E. WARNER.

Concrete for Small Jobs

ALTHOUGH CONCRETE is widely used in all industries its preparation for small jobs does not often receive the care and thought that it should unless the plant happens to be large enough to have a construction engineer who deals in the preparation and mixing of it continually. A common rule of thumb concrete is a 1:2:4 mix which is used for all and every job irrespective of the use or the condition of the sand and aggregates.

The sand or fine aggregate commonly ranges in size up to about ¼ in. Coarse aggregate may run up to several inches but stock sizes run from ¼ to ½, 1 or 2 in. for use in small sections, general work and mass work respectively. The function of the coarse aggregate is to fill up space and reduce shrinkage so that if good clean and solid rock is available the maximum useable size is determined by the forms and reinforcing.

Naturally the sand and gravel should form as dense a mass as practical. This means a well graded material which fills up most of the voids and so leaves less room to be taken up by the cement. A good natural gravel may run for instance 25 per cent from ¼ to ½ in., and 25 per cent from ¾ to 1¼ in. Sand is usually available in three stock sizes, fine for plaster work, medium for general construction and coarse for paving.

As density of the aggregate is derived it is well to determine the best proportion of sand and gravel available by experiment starting out with 25 or 30 per cent sand and gradually increasing the proportion until the most dense mix is found. This mixture will require the least cement.

It is of course foolish to try to skimp on the amount of cement used, especially on small jobs where the added cost is negligible. The proper amount of cement is however important for other reasons. A rich mix will be stronger, denser and more watertight and will also be easier placed but it will have a greater tendency to shrink and crack when it dries out. A sand mortar will shrink twice as much and a neat cement grout will shrink four times as much as concrete. Lean mixtures are hard to work.

Approximate mixes for various uses are given by the accompanying table (from Bulletin 27 of Purdue University). The difference between the amount of water to be added and the total required is due to the water in the aggregate. The table allows about 0.5 gal. of water for each cubic foot of sand and a

KIND OF WORK	CONSISTENCY	SIZE OF LARGEST AGGREGATE INCHES	APP. MIX LOOSE VOLUMES	SACKS CEMENT PER CU. YD. OF CONCRETE	GAL. WATER TO ADD TO EACH 1 SACK BATCH	TOTAL WATER NECESSARY
Small precast work Posts Sills and lintels Very thin sections	Soft	3/8 to ½	1:2:2	7½ to 8	3½ to 4	5
Tanks and cisterns Watertight work	Med. to soft	3/4 to 1	1:2:3	6½ to 7	4 to 4½	5½
One course sidewalks Floors on the ground Driveways Steps	Stiff to med.	1½	1:2½:3½	6 to 6½	4½ to 4¾	6
Building foundations Building walls Retaining walls Culverts Machine bases	Med. to stiff	1½	1:2½:3½	5½ to 6	4½ to 5	6½
Reinforced work Floors Beams Columns	Med. to soft	3/4 to 1	1:2½:3½	5½ to 6	5 to 5½	7

pint for each cubic foot of coarse aggregate. It is suggested that for general purposes the use of a 1:2½:3½ mix with about 4½ to 5½ gallons of water per sack of cement is best. The exact amount will depend upon the condition of the aggregate as sand will contain from a quart to a half gallon of water. The final mix should place easily in the form, if too dry the form will not fill and if two mushy the cement will run off leaving the coarse aggregate exposed. A medium consistency is good for most general use. When dumped out of an ordinary pail it should slump over but maintain a well defined mound. The mortar should not run out but the top should show a grainy top surface.

Curing should be carefully done by keeping the top and sides wet for several days by covering with wet dirt or old sacks. In cases where the time is limited special quick drying cement is obtainable. In general it seems that concrete engineers rather frown on the addition of various materials or admixtures as they are commonly called. These vary widely from such things as flue dust and cinders, usually added to decrease the weight, to soap, rubber and even sugar. The best known and most useful are apparently calcium chloride and calcium hydroxide. Some of these admixtures are to increase the strength, some the workability or water resistance or to give color. Calcium chloride speeds up the hardening of concrete and if a liberal layer is spread on top after the surface is finished it will be found to give a much quicker set and a hard surface particularly useful for floors and surfaces receiving hard wear. Carborundum dust is also effectively used for this service.

Curing should start within a few hours or as soon as the finished surface starts to set so that it will not be damaged. This decreases shrinkage and cracking and also increases the strength. It is best to protect the green surface so that the spray will not wash out the cement on the top.

Brooklyn, N. Y. P. F. ROGERS.

MAGNET steels, designated "MK Steel" by the inventor, Dr. T. Mishima of Tokyo Imperial University, are announced in the Japanese magazine Ohm. These are alloys of iron, nickel and aluminum, suitable for casting but not readily forged. They require only annealing to develop best magnetic activity which is stated to be 9 times that of tungsten magnet steels and 2½ times that of cobalt steels. Magnetic properties are said to be unaffected by temperature change or vibration.

New Equipment

Foxboro Controllers

Two NEW control instruments have been developed by the Foxboro Co. of Foxboro, Mass. Their appearance is practically identical but one controls temperature, the other pressure. These two controllers will be found particularly useful where dependable control at a definite point must be had inexpensively.

The dial and knob on the lower face of the controller permits adjustment of the temperature or pressure within the range of the instrument. The indicating gage

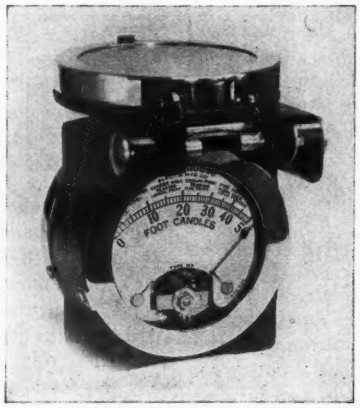
above the adjusting knob shows the air pressure on the diaphram motor of the control valve and also shows whether the valve is opening or closing.

On the temperature controller, a 2-in. dial type thermometer may be installed in place of the air gage. This thermometer is connected to the same bulb as the controller thus showing the temperature being maintained.

The pressure controller may be equipped likewise with a high pressure indicating gage that shows the pressure being controlled. In either case, it is necessary to mount a valve motor air gage on the air line to the valve outside the case.

Westinghouse Right Light Meter

WESTINGHOUSE ELECTRIC & MFG. Co., East Pittsburgh, Pa., announces the development of a Right Light meter for measuring light intensities and making illumination surveys. Only a few seconds are needed to check lighting conditions at any point, since the



dial is marked in foot candles with zones denoting the minimum amount of light needed for specific types of work.

This new foot-candle meter uses the new Westinghouse Photox cell, a recently developed photo-voltaic cell, which changes light directly to electric current without any auxiliary electrical supply. The Photox cell and the microammeter which measures the cell current are mounted together in a neat moulded case.

The scale is accurately calibrated in foot-candles and is also divided into sections indicating the minimum amount of light considered satisfactory for various kinds of work and conditions. The instrument is a sensitive micro-ammeter of a new design made to withstand severe portable service.

The cell consists of a disc of copper oxide on copper, properly aged and treated to stand long use without aging or changing calibration.

Monobelt, a New Type of Leather Belt

ALEXANDER BROTHERS, Inc., Philadelphia, Penna., has recently developed a new type of leather belt which, it is claimed, attains three objectives: Increase of adhesion, reduction of stretch and reduction of internal friction.

In the construction of this new belt, specially prepared vegetable tanned leather having a high adhesion and thoroughly stretched by a special process is exclusively used. The stretch is accurately regulated in each piece of leather. In single ply belts, leather with the minimum of stretch is used. In double ply belts, the pulley side of the belt is made of the same leather as the single ply, but the outer ply is made of more elastic leather, that is, leather having more elastic stretch than the inner ply thus preventing crumpling of the inner ply as it passes over a pulley of small diameter.

This new belt has been called Monobelt, that is the one belt which answers the purpose for practically all regular drives, or drives consisting of only two pulleys. For conditions where the belt is subjected to a reverse flexing, however, such as idler pulley or serpentine drives, this type of belt should not be used.

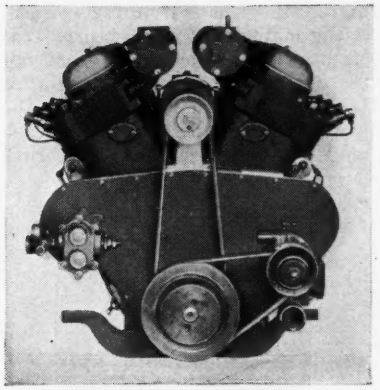
The G. E. Impulse Breaker

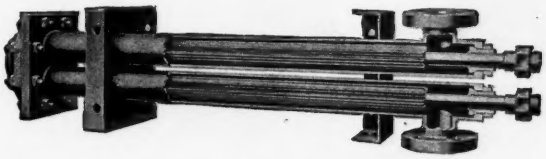
A NEW HIGH VOLTAGE, large capacity oil circuit breaker, containing many unusual and new features has been announced by the General Electric Company. Radically different in design, each single-pole unit of the new breaker is shaped like a cross in contrast to the tanklike construction of conventional equipment. Higher breaking speeds with short arcing times and the use of very little oil are among the distinct advantages offered by the new equipment. Only 96 gal. of oil per pole are required by a breaker with an interrupting rating of 1,500,000 kv-a. at 138 kv. compared with approximately 1700 gal. per pole for a conventional breaker of an equivalent interrupting rating.

Horizontal containers, not much larger than conventional bushings, enclose the interrupting mechanisms. These containers are mounted on vertical central supports which, in addition to serving in an insulating capacity, also house current transformers when such equipment is required. The operating mechanism is located in the base of each single-pole unit and an insulated operating rod passes up through the central support to the container. The interrupting elements consist of several sets of contacts in a line and the inside of each container is so arranged that oil, driven by a piston, is positively directed across the arc path of each of the several arc breaks per pole during circuit interruption.

Oil Heater

FUEL OIL HEATERS of a new type have recently been placed on the market by The Griscom-Russel Co., 285 Madison Ave., New York, N. Y. This apparatus is the twin G-Fin section, consisting of two parallel steel pipes, each serving as a shell for a single pipe with a return bend at one end and all inlet and outlet connections at the other end. The G-Fin pipe is made in the form of a U-bend or hairpin, each leg of which is contained in one of the two parallel pipe shells.





These units, being standard and interchangeable, can be arranged in series or parallel as required by the duty, and additional sections can be connected at any time to an existing installation. An important advantage of the design is that it eliminates the necessity of providing 100 per cent spare heating capacity except in installations consisting of only a single unit. Further advantages of the heater are the absence of internal joints which might permit leakage between steam and oil, the elimination of strains from changes in temperature because of the free expansion of both shells and G-Fin Pipe, the ready accessibility of the entire heating surface for inspection and cleaning, and the light weight which permits easy handling and installation.

V-Eight Diesel

HILL DIESEL ENGINE CO., Lansing, Mich., has recently added a new eight cylinder V type engine to its line of Diesels. This V-8 engine is a 5 in. bore, 7 in. stroke, rated at 200-hp. at 1700 r.p.m. The cylinder is cast en bloc at an angle of 30 deg. from the vertical, a construction which provides minimum overall length and width with maximum rigidity. The engine is available in two types, cast iron weighing 2500 lb. and aluminum weighing 2000 lb.

Lubrication is accomplished by a dry sump pressure system. Cylinder heads and cylinders are cast of chrome nickel alloy iron, completely water jacketed. Silchrome valves and vanadium steel springs are used. Camshaft is of heat treated steel machined throughout. Pistons are cast of Lo-ex aluminum alloy equipped with four compression and one oil ring. Accurate speed control over the entire range is accomplished by a governor mounted in the V between the cylinder blocks. The engine will operate satisfactorily on fuel oils of 22 deg. Baumé or lighter up to and including kerosene. The 32-v. starting motor is equipped with Bendix friction gear meshing with a ring gear on the flywheel. The new engine is equipped with standard Hill fuel system and Bosch injection pumps. For marine service the engine is available with reverse and reduction gears.

Temperature Control

ELECTRIC TEMPERATURE REGULATORS, comprising automatic valves for steam, gas, oil, water or brine flow control, actuated by thermostats of various kinds has been placed on the market by the Wilbin Instrument Corporation, 40 East 34 St., New York City.

Instead of the conventional rotary motor, a heat motor is employed to operate the valve. This motor consists of a pressure chamber in which a volatile fluid is vaporized by an electric strip heater. The vapor pressure built up compresses a flexible bellows to which the valve plunger is attached.

Limit switches, actuated by the valve stem itself, control and reverse the valve stroke. A device for interrupting the electric circuit makes it possible to arrest the valve travel at any point between the "open" and "closed" positions. It is claimed that six different valve positions can be secured for a total temperature difference at the thermostat of only 1 deg.

Combinations are available suitable for all process industries, refrigeration, air conditioning, whether and zone control of heating systems, ovens and room control. Two types are available Type C, as illustrated for throttling control of temperature from—40 to + 650 deg. F. and Type E having only an open and shut position.

New Thyrite Station-Type Lightning Arresters

IMPROVEMENTS IN both protective performance and mechanical construction have been incorporated in the new Form D Thyrite station-type lightning arresters of the General Electric Company, and the exclusive no-time lag feature has been continued. The impulse breakdown voltage of the 11.5-kv. unit is about 40-kv. crest. When applying A.I.E.E. standard surge current (1500 amp.), the impulse voltage across the arrester unit is limited to only 36-kv. crest—little more than two times the crest rating of the arrester, and representing an improvement of 30 per cent over previous designs. The sealed construction of the series gap protects the gap elements from moisture or atmospheric influences.

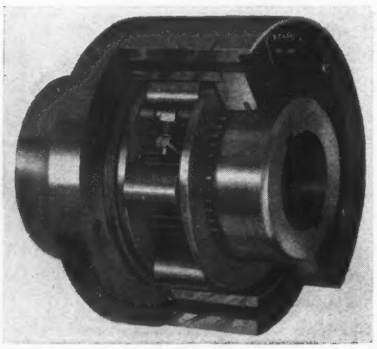
The new arrester embodies unit construction, an exclusive Thyrite feature, whereby standard 11.5-kv. arrester units are common to, and interchangeable in, arresters of all voltage ratings. Three-point support and bolting between units of

the new arrester simplify assembly and avoid mechanical strains on porcelains. Within the unit the series gap is hermetically sealed, metal caps being bottle-cap-crimped over the ends of the porcelain container, with the gaskets permanently locked in their original compressed position, excluding moisture and making the arrester operation independent of atmospheric influence.

The interior elements of the new arrester can be put readily into the unit housings of existing arresters, thereby enabling Thyrite arresters now in service to be modernized to incorporate the advanced protective performance of the new arrester and the advantages of the new sealed gap.

Morse-Kelpo One-Way Clutch

MORSE-KELPO CLUTCH is a new product developed by the Morse Chain Co., Ithaca, N. Y., Division of Borg-Warner Corp., which is a positively actuated one-way clutch, free-wheeling in one direction, but driving in the other. Operating with no back-lash, it is ideal as a ratchet drive. Used to connect two



prime movers to a common load, either will pull the load but neither can drive the other. This dual drive finds frequent application for two motors or motor and turbine driving force or induced draft fans, for auxiliary stand-by drive, and for booster drives for starting heavy machines such as printing presses, paper mill and steel mill machines.

Morse-Kelpo Clutch is built of alloy steels, hardened and ground to close limits of accuracy, and its exclusive feature is automatic compensation for wear.

Brush Seater

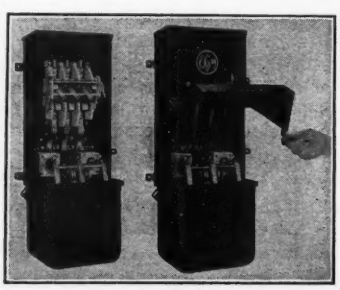
THE NEW BRUSH SEATER recently placed on the market by the Ideal Commutator Dresser Co. of Sycamore, Ill., is a soft abrasive insulating material of fine texture. It is claimed by the manufacturers not to scratch or cut the commutator. It is applied by simply holding the brush seater at the heel of the brush and pressing down on the brush

while the latter is actually in use. The friction from the revolving commutator, or ring, releases the brush material which is carried under the brush. The combination of the material removed from the brush and the brush seater is said to impart a high polish to the commutator or ring.

New Across the Line Starter

FOR MOTORS up to 30 hp., 220 v., 60 hp., 440 v., and 75 hp., 550 v., The Electric Controller & Mfg. Company, Cleveland, Ohio, announces a new oil-immersed, across-the-line, combination magnetic starter. This starter, a larger companion for the No. 1 Type ZOS Starter recently announced, contains an unfused or fusible safety switch and a magnetic starter with overload relays. All of the internal wiring of these starters is complete.

Although designed for the severe service encountered in mill duty, these starters are exceptionally small and narrow, having safety switch front operated and a cover that swings vertically.



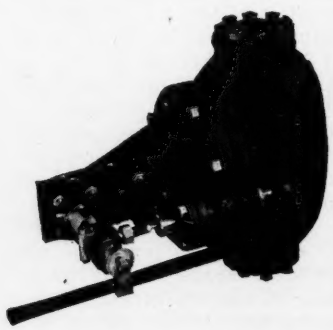
Pipe Coupling

JOINING of straight plain end pipe without grooving, threading, beveling or upsetting the ends, and with no extra finishing operation is made possible by the Champion positive seal pipe coupling, manufacturing by The Champion Machine & Forging Co., Cleveland, Ohio.

Coupling consists of five distinct parts, viz: two half coupling sections which contain gripping devices, one gasket with metal protected sections and two bolts. Coupling sections are drop forged special grade steel; gripping rings are drop forged and heat treated and assembled into half coupling sections in such a manner as to become integral with coupling itself.

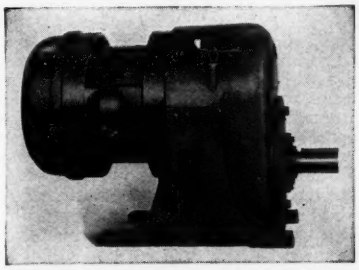
Ball Bearing Liquid Level Control

WITH A FLOAT chamber equipped with full ball bearing construction of stainless steel balls and races, the new remote control for liquid level, developed by the Swartwout Co., Cleveland, O., eliminates friction caused by liquid under pressure. It will operate valves controlling the flow of liquids to tanks, condensers, receivers and other vessels at any distance up to 300 ft. and the construction permits pressures up to 450 lb. per sq. in. The operating mechanism is fully enclosed but easily accessible for adjustment and the stuffing box may be grease sealed.



Single-Reduction Gearmotors

THE RELIANCE ELECTRIC & ENGINEERING Co. of Cleveland, Ohio has recently added single-reduction units to their line of gearmotors. These are used for ratios up to 6:1 inclusive. They can be furnished with both alternating and direct current motors of various types in sizes rated ¾ hp. and up. Multi-

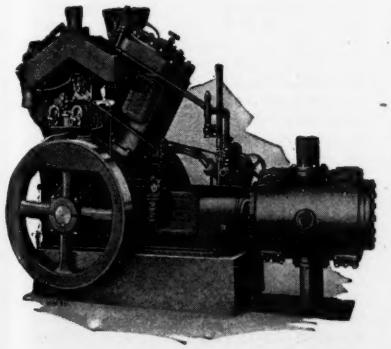


speed and adjustable-speed motors may be used. The entire reduction is obtained in a single pair of gears. Substantial feet, cast integral with the gear housing, afford a solid support close to the point of maximum torque application. Ball-bearings are used throughout. Motor parts, and gears may be readily removed and assembled.

Some advantages of these combined units are lower first-cost, reduced space, lower installation and maintenance expense.

Air Compressor

IN THE FIELD of air and gas compressors, Ingersoll-Rand Co., Phillipsburg, N. J., offer the Type XVG, a complete new line of direct-connected gas engine driven compressors. The units consist of vertical 4-cycle, multi-cylinder, V type gas engines with direct-connected standard horizontal com-



pressor cylinders. The XVG is built in four sizes of 60, 125, 190 and 260 hp., with 2, 4, 6 and 8 power cylinders respectively, two power cylinders for each compressor cylinder.

New Condit Motor Operator

OUR ATTENTION has been directed to an error which appeared in the news item describing the type UC-30 motor operator made by the Condit Electrical Mfg. Corp., on page 154-5 of the March issue. In this item it is stated that closure is effected in approximately 8 seconds. This is an error. The item should have read, closure is effected in approximately 8 cycles.

Appalachian Electric Power Co. Denied Appeal

THE APPALACHIAN ELECTRIC POWER Co. received a refusal to review from the United States Supreme Court, February 20, in its appeal from the decision of the Federal Court in the Virginia District, allowing the Federal Power Commission authority to supervise power projects on non-navigable rivers. This legal battle has been on for about a year and was a challenge to the Commission authority, which brought up the question of the constitutionality of the recapture provisions of the federal power act and the validity of the commission's findings on its authority to control the company's $11,000,000 project on the New River in Virginia. This river empties into Kanawha River, which is a navigable river. The Commission indicated that it was willing to grant the Power company a limited license providing the government might recapture the project at the end of 50 yr. The license provided for a control of the costs of construction and supervision over power, light and general rates that the company should charge.

Willard Elected U. of I. President

ARTHUR CUTTS WILLARD, Acting Dean of the College of Engineering of the University of Illinois, has been chosen as president of that institution to take office on July 1. Mr. Willard is a graduate of the Massachusetts Institute of Technology, and with wide experience as a consulting engineer, particularly in the heating and ventilating field, entered the faculty of the university in 1913 as assistant professor of the department of mechanical engineering. Since that time he advanced to the position of acting dean of the college of engineering. Mr. Willard has written many articles and society papers and with L. A. Harding as co-author has written several editions of their book entitled Mechanical Equipment of Buildings.

Robins Acquires Mead-Morrison Co.

ANNOUNCEMENT is made by the Robins Conveying Belt Co., of New York City, that it has acquired the coal and ore handling business of the Mead-Morrison Manufacturing Co., of Boston, which will be operated in the future as the Mead-Morrison Division of Robins Conveying Belt Co.

Both of these companies are well known in the materials handling field, the Robins Co. having been a pioneer in the development of the belt conveyor and Mead-Morrison the use of grab buckets for unloading coal and ore from vessels.

This consolidation gives to the Robins Co. a complete line of material handling machinery, including Mead-Morrison unloading towers, stocking and reclaiming bridges, pivoted bucket carriers, cableways, and car and barge hauling equipment, in addition to the Robins belt conveyors, crushers, screens, skip hoists and other units.

Lamme Medal Awarded to Lewis B. Stillwell

THE 1933 LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to Dr. Lewis B. Stillwell, New York, N. Y., "for his distinguished career in connection with the design, installation, and operation of electrical machinery and equipment", and will be presented at the Summer Convention of the Institute, which is to be held at Hot Springs, Va., June 25-29, 1934.

Lewis Buckley Stillwell, consulting engineer, New York, N. Y., was born in Scranton, Pa., March 12, 1863. He was a student in the Latin-Scientific course at Wesleyan University, Middletown, Conn., 1882-84, and took a special course in electrical engineering at Lehigh University, Bethlehem, Pa. His degrees are: E. E., Lehigh University, 1885; M.S., 1907; D. Sc., 1914; and Sc.D., Wesleyan University, 1907.

From October, 1886, to April, 1891, he was employed as assistant electrician of the Westinghouse Electric & Manufacturing Co., and

served as chief electrical engineer of that company from 1891 to 1897.

He was an outstanding leader in the development of alternating current, and had an active part in the determination of Westinghouse policy with respect to system development engineering and the establishment of 60 and 30 cycles as standard frequencies.

His contributions, as Westinghouse engineer, to the general layout and design of the first plant of the Niagara Falls Power Co., led to his appointment as electrical director of the latter company, which position he held from 1897 to 1900.

Mr. Stillwell began his practice as a consulting engineer in New York City in 1900, and has filled engagements with many companies on large and important engineering projects.

Frank R. Wheeler

FRANK R. WHEELER, prominent figure in the power plant industry as a specialist in condenser and heat transfer equipment for over thirty years, died at his home in

Chicago on March 1st. He graduated from Stanford University in 1902, and following four years' general engineering experience as Vice-President of the Tracy Manufacturing Co. of California, he became Pacific Coast Manager of the C. H. Wheeler Mfg. Co., and in 1910 Chicago District Manager. In 1928 he left Chicago to become Manager of the Condenser and Heater Departments of the Elliott Co. in Pittsburgh and in 1932 returned to Chicago as Special Middlewestern Representative of the Worthington Pump & Machinery Corporation. At the time of his death he was engaged in consulting practice. He belonged to the University Clubs of Chicago and San Francisco, Engineers Club of New York and A.S.M.E.

News From the Field

WILBUR G. HUDSON has been appointed Chief Engineer of Link-Belt Co.'s Pershing Road Plant in Chicago. Mr. Hudson, after graduating from Cornell, entered the employ of Link-Belt Co. at Philadelphia, as a draftsman. Later he did special development work under the direction of James Mapes Dodge, and subsequently was appointed General Superintendent of Erection. In 1908 he joined the Guarantee Construction Co., New York, as Vice-President. Later he became President of Wilbur G. Hudson Corporation. Outside of his work in materials handling, Mr. Hudson has also been Vice-President and Chief Engineer of the Curtiss-Wright Airport Corporation, in charge of the design and construction of their airports.

THE HAGAN CORPORATION, Pittsburgh, Penna., announces the appointment of E. W. Wagenseil to the newly created position of General Sales Manager of the Hagan Corporation and its subsidiaries—The Buromin Co., Hall Laboratories, Inc., and Calgon, Inc. The latter company has just been organized to market Calgon products. Mr. Wagenseil was engaged in sales and engineering work in the stoker field for many years before taking charge of Air Preheater Sales for Blaw-Knox Co. in 1927. Two years ago, Mr. Wagenseil left Blaw-Knox Co. to join the Sales Department of Hagan Corporation, handling combustion control and boiler water conditioning.

H. D. JAMES, control expert and long a consulting engineer of the Westinghouse Electric & Mfg. Co., has opened an engineering consulting service, specializing in industrial and building problems, with offices in the Gulf Building, Pittsburgh, Penna. For manufacturers without technical staffs, the organization offers technical information, assistance in purchasing where engineering questions are involved, cost analysis, and design of equipment. Experienced engineers working under Mr. James' personal supervision are available for special assignments, including electronic and air conditioning applications.

THE BABCOCK & WILCOX TUBE CO. announces that the territory served by its Tulsa Sales Office, managed by C. J. Hochenauer, has been enlarged to include the State of Oklahoma and the Southern half of Kansas.

GARDNER C. DERRY, who has been sales manager of the power division for the B. F. Sturtevant Co., Boston, Mass., has been elected vice president of this company.

F. E. HARRELL has been made Assistant Chief Engineer of the Reliance Electric & Engineering Company, Cleveland, manufacturers of electric motors. Mr. Harrell joined the Reliance organization upon graduation from Purdue University in 1924. Following sales engineering work in Chicago he returned to Cleveland as special engineer for steel-mill motor applications. He has since been Chief Draftsman and Engineer in Charge of A-C Design.

J. L. VAN NORT is now with the Chicago Office of the Reliance Electric & Engineering Company as a sales engineer. Previously Mr. Van Nort has represented the Reliance Company in the New England and Cincinnati Districts.

BRADSHAW & Co., Pittsburgh, Penna., has been appointed representative for the DeWolf Furnace Corp. of Rochester, New York, to handle its products in Western Pennsylvania, Eastern Ohio and all of West Virginia.

WALTER D'ARCY RYAN, famous General Electric illuminating engineer, regarded as the man who first made artificial illumination both a science and an art, died at his home in Schenectady, March 14, of heart trouble. He was first stricken last summer while occupied at the Century of Progress Exposition at Chicago as director of lighting. Although he recovered from earlier attacks of the disease, a blood clot complicated his condition when he suffered another attack.

For the Engineer's Library

DETERMINATION OF CARBONATE, PHOSPHATE AND HYDROXIDE IN BOILER WATERS. By E. P. Partridge and W. C. Schroeder. Published by the American Society of Mechanical Engineers, 29 W. 39th St., New York, 8 by 10½ in., paper bound, 96 pages. Price, $2.00.

Reports of research results published as a progress report by the subcommittee on water analysis of the joint research committee on boiler feedwater studies. Laboratory procedure for the determination of carbonate, phosphate and hydroxide is given in considerable detail, together with report of the research work and an extensive bibliography.

PATENT APPLICATIONS. By Charles W. Rivide. Published by The Michie Co., Charlottesville, Va. Size 6 by 9 in., cloth, 397 pp. plus 87 pp. of index. Price, $7.00.

It is unusual to find a book on this subject dealing with details and written in such language that it is readily understandable to the average reader yet of value to the practicing lawyer. This book does that by dealing with fundamental principles illustrated by well chosen illustrations. "Technical men as a general rule do not have sufficient familiarity with the principles of patent law to be able to determine for themselves with any degree of certainty whether their creations are of a patentable value," says the author. Undoubtedly that is true and probably as much money is wasted on useless patents as is lost through failure to patent ideas. To those interested in creative work of any kind the book should be invaluable, to others the working of this important branch of our government should be of interest. It is said that the inventing bug bites everyone at least once so preparedness is not altogether out of place.

BOILER REFERENCE BOOK. Published by John S. Swift Co., Inc., 105 S. 9th St., St. Louis, Mo. 5¼ by 8 in., 400 pp. Paper bound. Price, $1.00.

A compact compilation of boiler data

covering heating boilers manufactured by some 35 manufacturers. Information includes heating surface, grate area, manufacturer's rating and in many cases data regarding the probable efficiency, required draft, chimney size etc. It is intended as an information book for oil burner, stoker and gas burner salesmen, architects, engineers, inspectors and the building trade in general.

BULLETIN No. 259, "Oscillations due to Ionization in Dielectrics and Methods of Detection and Measurement," by J. T. Tykociner, H. A. Brown and E. B. Paine, and Bulletin No. 260, "Investigation of Cable Ionization Characteristics with Discharge Detection Bridge," by H. A. Brown, J. T. Tykociner, and E. B. Paine, have been issued by the Engineering Experiment Station of the University of Illinois.

The principal aim of the investigation described in Bulletin No. 259, "Oscillations Due to Ionization in Dielectrics and Methods of Detection and Measurement," by J. T. Tykociner, H. A. Brown, and E. B. Paine, and No. 260, "Investigation of Cable Ionization Characteristics with Discharge Detection Bridge," by H. A. Brown, J. T. Tykociner, and E. B. Paine, of the Engineering Experiment Station of the University of Illinois was to develop a rational method of testing insulation as an aid to engineering practice in the manufacture and operation of cables.

It is known from every-day engineering experience that condensers and cables break down under the stress of high potentials and that the breakdown is caused by the deterioration of the insulating properties of dielectrics. Such deterioration occurs as the result of cumulative action of ionization in gaseous films and bubbles embedded within dielectrics. The degree to which a dielectric may be freed from such inhomogeneities would depend largely on the possibility of determining the starting point and intensity of ionization. It is necessary, therefore, to find reliable methods of detecting and measuring ionization in dielectrics.

In Bulletin No. 259 a general discussion of the principle is given, and of its application to the testing of cable insulation, followed by a description of some of the methods and devices developed for the detection of ionization. Bulletin No. 260, as its title indicates, deals with the investigation of ionization in cables by means of one of these devices, the discharge-detection bridge.

For a limited time copies of Bulletins Nos. 259 and 260 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., has just issued a bulletin on the Type UB Worthington centrifugal pumps of the two-stage volute type, which contains illustrations and specifications for these units.

THE BORDEN CO., Warren, O., has just issued its Catalog No. 34, dealing with The Modernized Line of Beaver Pipe Tools. This not only illustrates and describes the various tools but gives prices, sizes and weights as well.

MORRIS MACHINE WORKS, Baldwinsville, N. Y., describes in a new bulletin the company's double-suction, horizontally-split centrifugal pumps, and outlines the important advances in design which have taken place in the past few years. The book also gives precautions that should be taken in the installation and operation of centrifugal pumps and diagnoses the most common causes of service interruption.

INGERSOLL-RAND CO., New York City, has recently issued two bulletins, one designated as No. 2070 dealing with the Cameron Motorpump which is a complete pumping unit with built-in electric motor and pump rotor on the same shaft; the other designated as bulletin No. 2078 is entitled "Modern Boiler Feed Pumps for pressures up to 600 lb." and describes the Cameron type NT multi-stage centrifugal pumps, a feature of which is that the hydraulic balance is obtained by placing an equal number of impellers back to back.

VIGILANT FEEDWATER REGULATOR and other steam specialties made by The Chaplin-Fulton Manufacturing Co., Pittsburgh, Penna., are represented in a new, clearly written, completely illustrated and well-arranged catalog of 60 pages just offered for distribution. The new catalog directs attention to the long history and established reputation of the firm, which was organized in 1884.

INGERSOLL-RAND CO., New York, briefly describes two forms of water-vapor refrigeration apparatus, the Steam-Jet Refrigeration Unit and the Centrifugal Water-Vapor Unit, in its bulletin No. 2083 recently issued. Both accomplish the same purpose, viz., the cooling of a large quantity of water by the evaporation, in a high vacuum, of a small portion of the water.

THE LOUIS ALLIS CO., Milwaukee, Wis., has just published two new converter bulletins. Bulletin No. 509-A completely illustrates and describes construction, operation and uses of various types of Frequency Converters. Bulletin No. 502-B illustrates and describes Inverted Rotary Converters.

BLAW-KNOX CO., Pittsburgh, Pa., has recently issued two bulletins, one entitled "Blaw-Knox Desuperheaters" and the other "Blaw-Knox Contactors." These bulletins illustrate and describe the company's products that go under these names and point to the uses for which they are applicable.

FREYN DESIGN, No. 11, issued March, 1934, by the Freyn Engineering Co. of Chicago, contains several articles of interest to steel mill engineers. This publication will be sent gratis to readers interested in this field..

PYRANOLS, COOLING and insulating matrials which have, in addition to the desirable characteristics of mineral oil, the distinctive properties of being noninflammable and nonexplosive, are described in General Electric's new Bulletin GEA-1886. Approximately 75,000 kv-a. of Pyranol capacitors and transformers are in service.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wisconsin has recently issued bulletin No. 149-A "Equipment for the Modern Brewery and Malt House," which is a revision of a previous bulletin on this subject. It describes equipment for the power, electrical, pumping and other requirements of the brewing industry.

ALLIS-CHALMERS MFG. CO. has published a new bulletin No. 1165 illustrating and describing its line of Bracket Bearing Synchronous Motors. In addition to the standard line of motors for general requirements, including exciters, control equipment, etc., the bulletin also treats motors with special features of construction, such as anti-friction bearings, enclosed collector rings, splash-proof type, enclosed fan-cooled type, and vertical motors.

It contains a discussion of use of the synchronous motor for improvement of power factor with examples applying the graphical method for figuring power factor corrections.

A NEW CATALOG covering the complete line of oil circuit breakers up to 50,000 kv-a. has recently been issued by the Westinghouse Electric and Manufacturing Company. Included are tables which give the proper type of breaker, indoor, outdoor, or subway for any kv-a. needed. Also, a complete table of contents, with reference to specific sections for each type of breaker is included.

A 32-PAGE illustrated publication, entitled Westinghouse In the World of Lighting, has recently been issued by the Westinghouse Electric and Manufacturing Company. Outstanding developments in illumination are illustrated some of the most outstanding installations reaching a climax with the lighting of the Century of Progress. Floodlighting, bridge and street lighting, signs, commercial lighting, industrial lighting, aviation field lighting, fountain lighting, swimming pool and stadium lighting and home lighting are illustrated.

AN ILLUSTRATED 28-page bulletin describing welding equipment and applications of welding in the construction fields has been published by the Westinghouse Electric and Manufacturing Company. Many typical and outstanding construction jobs are shown. Also, endorsements of some leading structural engineers are included.

AN ILLUSTRATED 4-page leaflet entitled, Ignitron Welding Timer for Spot Welding, has recently been issued by the Westinghouse Electric and Manufacturing Company. This radically new and improved electronic controller is suitable for use in spot welding production work for joining all types and forms of materials. The distinctive features, construction, operation, and application are described.

WESTINGHOUSE two wire visicode and audicode supervisory control are fully described in a 10-page publication released by the Westinghouse Electric and Manufacturing Company. This simplified and sure means of obtaining remote indication of apparatus units is especially applicable for railway, railroad, central station, substation, and oil and gas pump line operation.

THREE NEW PUBLICATIONS describing the new line of Westinghouse fractional horsepower motors have been released. Many improvements over preceding designs have been incorporated making the motors more efficient and trouble free. Leaflet 20606 describes type FS polyphase squirrel cage motors for all voltages and frequencies, two and three-phase, ⅛ to ¾ hp. ratings. Leaflet 20604 describes type FR repulsion start induction motors for high torque, constant speed service. They are rated for single phase, 110 and 220 v., ⅛ to ¾ hp. service. Leaflet 20605 describes the type FK direct current motors for shunt compound and series wound service. They are rated for 32, 115 and 230 v., 1/30 to ¾ hp. service.

THE HAYS CORP., Michigan City, Ind., has recently issued its catalog RA-34 which deals with Hays combustion recorders, giving rather full and detailed descriptions of the various instruments made by this corporation, and illustrating the catalog thoroughly with half-tones and line drawings.

Power Plant Construction News

Ala., Russellville—Common Council is planning construction of new municipal electric light and power plant, estimated to cost $148,000. Fund is being arranged through Federal aid. It is proposed to begin work in near future.

Calif., Santa Monica—Douglas Aircraft Co., 3000 Ocean Park Boulevard, plans installation of electric power equipment in new one-story addition, 125x300 ft., to cost about $70,000. S. B. Barnes, 803 West Third Street, Los Angeles, is consulting engineer.

Colo., Fort Morgan — City Council plans extensions and improvements in municipal electric light and power plant, with installation of new turbo-generator unit. Fund of $75,000 is being arranged. George Cox, city superintendent, is in charge.

Ind., Indianapolis — A central steam power station will be installed in new eight-story department store to be constructed by William H. Block Co., 50 North Illinois Street, on adjoining site. It will cost about $1,000,000. Work is scheduled to begin soon. Vonnegut, Bohn & Mueller, Indiana Trust Building, are architects.

Iowa, Manning—Town Council has plans maturing for a new municipal electric light and power plant to cost about $135,000, with equipment. Federal aid in that amount is being arranged. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ky., Corbin—Corbin Brewing & Ice Co., recently organized, plans construction of one-story ice-manufacturing plant and boiler house, in connection with new local brewery. Complete brew house machinery will be installed. Entire project will cost over $150,000, with machinery. Ewing Wilder, Corbin, is president.

Ky., Stamping Ground — Buffalo Springs Distilling Co. plans one-story steam power house at proposed new local distilling plant. Electric power equipment will be installed for distillery service. Entire program will cost about $150,000. Walter C. Wagner, Breslin Building, Louisville, Ky., is architect.

Md., Baltimore—American Oil Co., American Building, is considering construction of new bulk oil storage and distributing plant in Curtis Bay district, consisting of main three-story unit, 100x150 ft., tanks, pumping machinery and accessory equipment. Estimated cost over $50,000. Company engineering department, in charge.

Minn., Ely—City Council will have plans completed early in the spring for a new municipal electric light and power plant, for which financing in amout of $1,700,000 is being carried out through Federal aid. Frederick C. Perry, Columbia Building, Duluth, Minn., is consulting engineer.

Mo., Kansas City—Hirsch Distilling Co., 401 Delaware Street, plans installation of electric power equipment in connection with an expansion and improvement program in three-story plant unit, 30x125 ft. Program will cost about $65,000. Mid-West Engineering Co., 3400 Troost Avenue, is consulting engineer.

Mo., La Plata—Common Council is arranging fund of $100,000, through Federal loan and grant, and bond issue, for a proposed municipal electric light and power plant, using Diesel engine generator units and municipal electrical distributing system. A special election has been called March 27 to approve program. E. T. Archer & Company, New England Building, Kansas City, Mo., consulting engineers.

Mo., St. Louis—Adolph Busch, Inc., 1109 Title Guarantee Building, Adolph Busch, president, recently organized, plans construction of boiler plant at proposed new brewery at Broadway and Catalan Street. Electric power equipment will be installed for brewing service. Entire project will cost close to $400,000. George E. Wells, Inc., Security Building, consulting engineer.

Mont., Lewistown — Lewistown Brewing Co., Gustave Hodel, president, recently organized, plans installation of electric power equipment, brewhouse and bottling machinery, etc., in connection with expansion and improvement program at local brewery, estimated to cost about $65,000.

N. J., Clifton — Standard Textile Products Co., 60 Clifton Boulevard, plans installation of electric power equipment in connection with rebuilding of local paint processing plant, recently damaged by fire, with loss reported at $25,000.

N. J., Jersey City—A central steam power station will be installed in proposed new Hall of Records to be constructed by the Board of Hudson County Freeholders, estimated to cost about $4,000,000. Financing in that amount will soon be arranged. John T. Rowland, 30 Journal Square, is architect.

N. J., Sayreville—Titanium Pigment Co., Inc., 111 Broadway, New York, a subsidiary of National Lead Co., same address, plans one-story steam power house at proposed new multi-unit plant at Sayreville, near Perth Amboy, N. J., where negotiations are under way for purchase of tract of about 400 acres of lands. New plant will be used for production of paint pigments, etc. Electric power equipment will be installed for operation. Entire project will cost over $1,500,000. Company engineering department is in charge.

N. J., South Amboy—Board of Public Works is planning installation of electric pumping machinery and auxiliary equipment at municipal water plant for increased capacity. Fund is being arranged for program.

N. J., Whippany—Dependable Insulation & Cork Co., Malapardis district, Hanover Township, near Whippany, plans installation of power equipment in connection with rebuilding of portion of plant, recently destroyed by fire. Loss about $27,000.

N. Y., Syracuse—International Harvester Co., 210 Teall Avenue, plans installation of motors and other electric power equipment in new one-story addition to local agricultural equipment manufacturing plant. It will cost over $100,000. Headquarters of company are at Harrison and Michigan Avenues, Chicago, Ill.

N. Y., Tonawanda—Eastern States Milling Corporation, Ontario Street and Cloverdale Road, plans installation of electric power equipment, elevating and conveying machinery, etc., in new 1,000,000-bushel capacity grain elevator. A building permit has been issued for unit. It will cost about $300,000.

N. C., Hickory — Walton Knitting Mill has plans for new one-story boiler plant in connection with new mill unit, 36 x 140 ft. Entire project will cost close to $30,000.

Ohio, Columbus—Farmers' Fertilizer Co. plans installation of power equipment in connection with proposed rebuilding of portion of local commercial fertilizer mill, recently destroyed by fire. Loss reported at $100,000.

Okla., Cushing—At a special election, citizens have authorized construction of a new municipal electric light and power plant to cost $280,000, with equipment. It is proposed to begin work on project at early date. Financing has been arranged.

Ont., East London — Hunt's Flour Mills, Ltd., plans installation of electric power equipment, elevating and other machinery in connection with proposed rebuilding of portion of plant, recently destroyed by fire. Entire loss reported over $200,000.

Ore., Portland—General Grocery Co., 2 North First Street, plans installation of electric motors, conveyors, elevators and other mechanical handling equipment in new three-story storage and distribution plant on Ash Street. Entire project will cost over $200,000. Work will soon begin. Sutton, Whitney & Anndahl, Lewis Building, city, are architects.

Pa., Allentown — Neuwiler Brewing Co., Allentown, plans installation of power equipment in new bottling plant addition to plant. Entire project will cost close to $40,000. Clarence E. Wunder, Architects' Building, Philadelphia, Pa., is architect.

Pa., Bristol—Rohm & Haas Co., 222 West Washington Square, Philadelphia, plans installation of electric power equipment in new three-story addition to chemical works at Bristol. Proposed to begin superstructure at once. Cost about $45,000, with equipment.

R. I., Westerly — Joseph Coduri Granite Works, Inc., Westerly, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire. Loss over $70,000.

S. C., Rock Hill—Common Council has preliminary plans under way for new municipal electric light and power plant, with initial capacity of 4,000 kw., using either steam or Diesel engine-generator units. A fund of $529,000 is being arranged for program through Federal aid.

Texas, McLean—Smith Brothers Refining Co., McLean, plans construction of new carbon black and gasoline plant in Wheeler County district, with air compressors and operating equipment to provide for capacity of about 75,000,000 cu. ft. natural gas per day. Entire project is reported to cost over $250,000.

Texas, Port Arthur — Texaco Can Co., a subsidiary of Texas Co., Houston and Port Arthur, plans installation of electric power equipment in connection with an expansion program at can-manufacturing plant. Entire project will cost over $45,000.